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COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

Global Radioxenon Emission Inventory for 2014

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Abstract

Global radioactivity monitoring for the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) includes the four xenon isotopes 131mXe, 133Xe, 133mXe and 135Xe. These four isotopes are serving as important indicators of nuclear explosions. The state-of-the-art radioxenon emission inventory uses generic release estimates for each known nuclear facility. However, the release amount can vary by several orders of magnitude from year to year. The year 2014 was selected for a single-year radioxenon emission inventory that avoids this uncertainty. Whenever 2014 emissions reported by the facility operator are available these are incorporated into the 2014 emission inventory. This presentation summarizes this new emission inventory. The overall emissions by facility type are compared with previous studies. The global radioxenon emission inventory for 2014 can be used for studies to estimate the contribution of this anthropogenic source to the observed ambient concentrations at IMS noble gas sensors to support CTBT monitoring activities, including calibration and performance assessment of the verification system as described in the Treaty as well as developing and validating methods for enhanced detection capabilities of signals that may indicate a nuclear test. One specific application will be the fourth ATM Challenge that is conducted in 2021.

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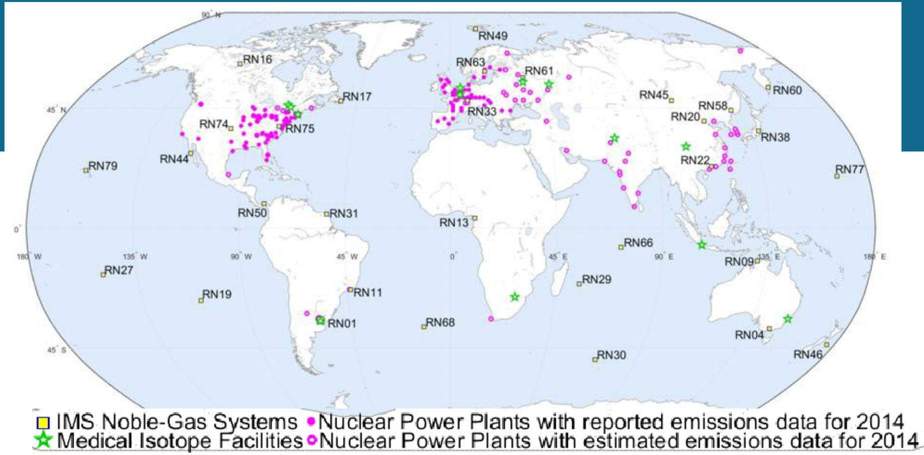
Summary of emission data



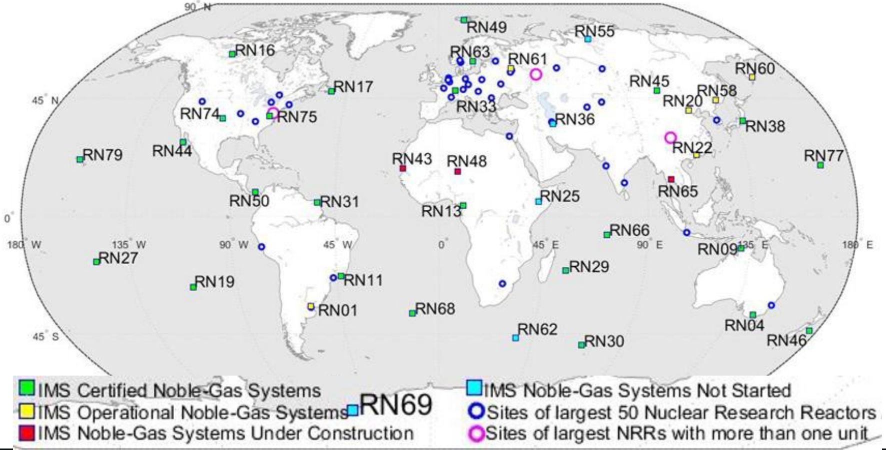
Status of the data

- Based on publicly available emission reports
- Published as peer-reviewed papers
- Data available as supplementary material in Excel

What sources are covered?

- All nuclear power plants
- All nuclear research reactors
- All known medical isotope production facilities

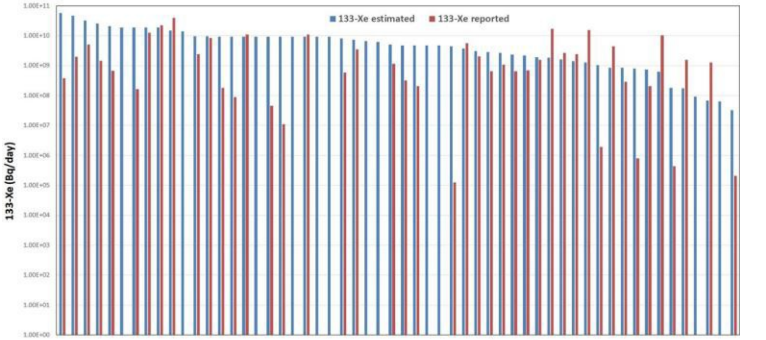
Thoughts about spallation neutron sources

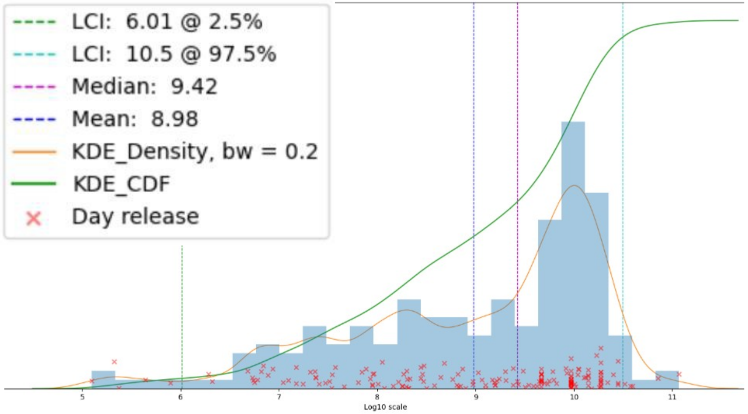


Lessons from NPP releases
(Kalinowski/Tatlisu, 2020)

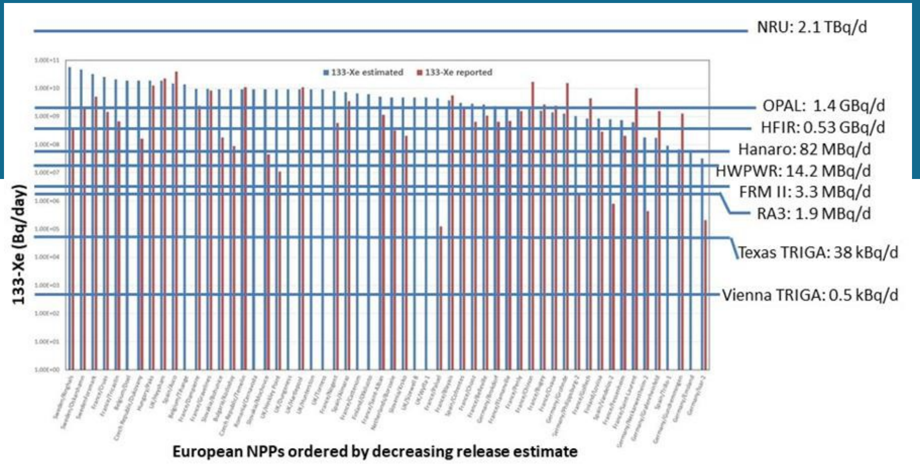
- Highly variable from year to year
  - For several NPP sites the reported Xe-133 release in 2014 is up to 4 orders of magnitude different from the best estimate (Kalinowski/Tuma (2009)
  - Not correlated with any facility parameter
  - Mainly influenced by tiny leaks through the fuel cladding

- Proposed solution
  - Don't use standard emission value
  - If available, use real annual reports (here: 2014)
  - Otherwise use probability distribution, e.g. kernel density estimate (Kalinowski/Liu, 2021)

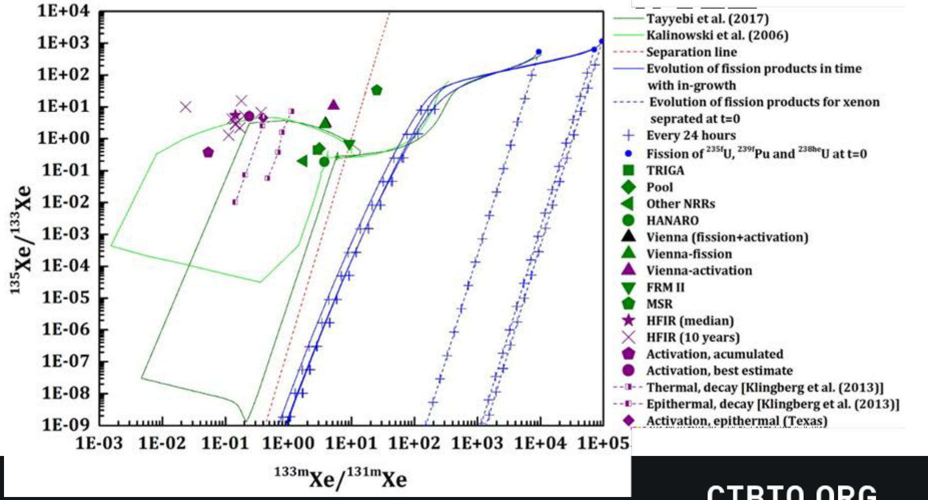




Lessons from NRR releases
(Kalinowski et al., 2021)



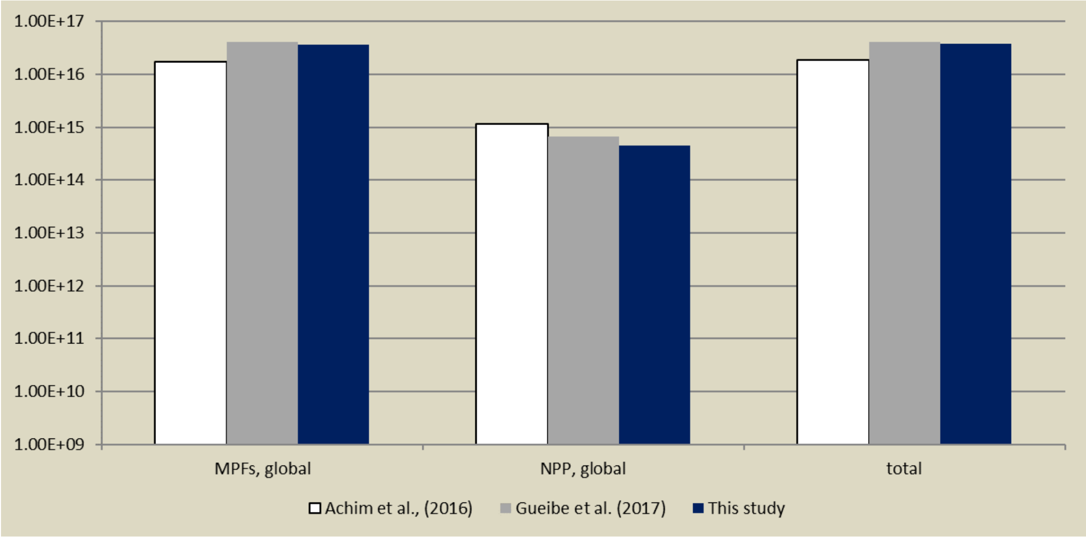
- Highly variable from reactor to reactor
  - Dependent on reactor type
  - Correlated with reactor power
- Findings
  - Strong NRR emitters release more than many NPPs (here: 2014)
  - Confirmed that activation may dominate (Klingberg et al., 2013)



Facility \ Xe-133 [Bq/year]	Achim et al. (2016)	Gueibe et al. (2017)
IRE in Fleurus, Belgium	9.86E+14	2.00E+15
CNL/MDS Nordion in Chalk River, Canada	5.99E+15	1.50E+16
NTP/NECSA in Pelindaba, South Africa	4.75E+15	2.30E+16
Curium, former Mallinckrodt		7.30E+11
ANSTO in Lucas Heights, Australia	7.30E+14	6.80E+14
PT BaTek (now PT INUKI) in Jakarta, Indonesia	1.02E+15	2.00E+14
CNEA in Ezeiza, Argentina	3.65E+14	7.40E+12
HFETR in Chengdu, China	3.65E+14	
PINSTECH PARR-1 in Islamabad, Pakistan	3.65E+14	
NIIAR in Dimitrovgrad, Russia	2.92E+15	
Nordion in Kanata (Ottawa), Canada		
Karpov Institute in Obninsk, Russia		

Lessons from MIPF releases
(Kalinowski/Tatlisu, 2018)

- Reports vs estimates
  - The estimated globally aggregated emission inventory is very close to the update based on real reported emissions in 2014.

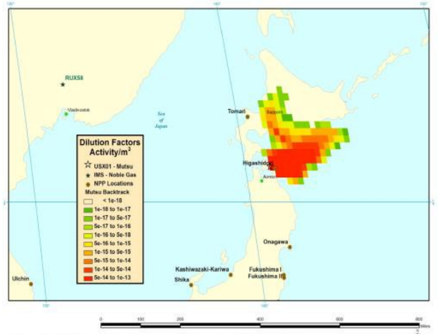


Other new thoughts

- NPPs may also have a strong contribution from activation to their releases.
  See SnT2021 presentation Tayyebi/Kalinowski: "*Radioxenon isotopic ratios from activation of stable xenon in releases from nuclear facilities in relation to fission sources visualized in multi-isotope-ratio plots*"

- Spallation neutron sources may cause remotely detectable releases.
  See SnT2021 presentation Kalinowski, et al.: "*Investigation of Xe-135 observations at IMS noble gas systems generated by neutron activation and its relevance for nuclear explosion monitoring*"

Remember: Bowyer et al. (2013)



24 hour Field-Of-Regard for detections of ^{135}Xe on June 11, 2012, at Mutsu

Summary

- The global emission inventory for 2014 from published sources and peer-reviewed scientific papers has been updated.
- Its first version was used for the 3rd ATM Challenge and the update will be applied in the Radioxenon Nuclear Explosion Signal Screening Inter-Comparison to be conducted in 2021. *(see presentation by Maurer et al. here on 26 May)*
- Several conclusions can be drawn from radioxenon emission data that are available that are important for effective nuclear explosion monitoring.

References

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