# Global radioxenon emission inventory for 2014

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## INDRODUCTION

Global radioactivity monitoring for the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) includes the four xenon isotopes $^{131m}$Xe, $^{133}$Xe, $^{133m}$Xe and $^{135}$Xe. These four isotopes are serving as important indicators of nuclear explosions.

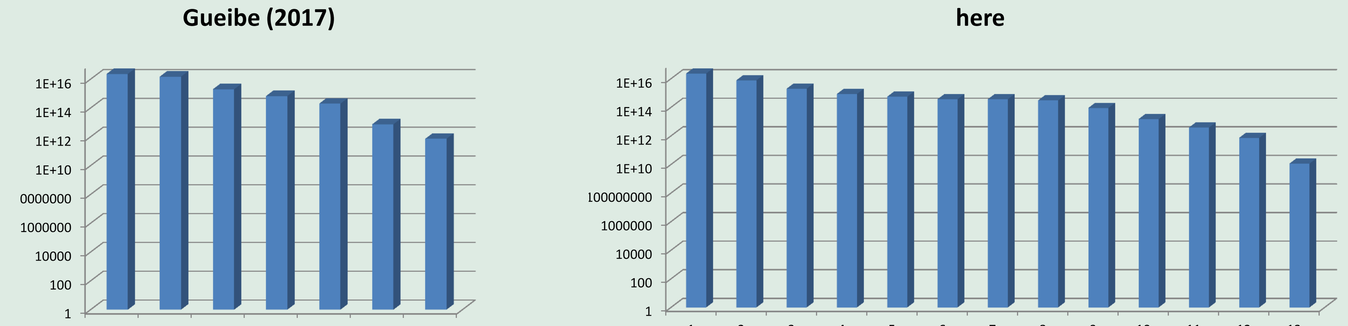
For the purpose of conducting the third ATM Challenge (Maurer et al., 2019), the global radioxenon emission inventory was updated as best estimate for 2014 releases. Whenever emissions reported by the facility operator were available these are incorporated into the emission inventory. This poster summarizes this new emission inventory. The overall emissions by facility type are compared with previous studies.

## MEDICAL ISOTOPE PRODUCTION FACILITIES (MIPF)

Thirteen MIPFs are included in this global radioxenon emission inventory. The table summarizes what status the new data set has in comparison to the best estimate of Gueibe et al. (2017). Only for two MIPFs there is no update. Six MIPFs were not included in the previous best estimate. The color coding shows for each isotope the confidence level of the data.

| | updated? | Xe-133 | Xe-131m | Xe-133m | Xe-135 |
|---|---|---|---|---|---|
| IRE in Fleurus, Belgium | Yes | | | | |
| CNL/MDS Nordion in Chalk River, Canada | Yes | | | | |
| Nordion in Kanata (Ottawa), Canada | New | | | | |
| NTP/NECSA in Pelindaba, South Africa | No | | | | |
| Curium, former Mallinckrodt | No | | | | |
| ANSTO in Lucas Heights, Australia | Yes | | | | |
| PT BaTek (now PT INUKI) in Jakarta, Indonesia | Yes | | | | |
| CNEA in Ezeiza, Argentina | Partially | | | | |
| HFETR in Chengdu, China | New | | | | |
| PINSTECH PARR-1 in Islamabad, Pakistan | New | | | | |
| NIIAR in Dimitrovgrad, Russia | New | | | | |
| Karpov Institute in Obninsk, Russia | New | | | | |
| Lantheus Medical Imaging | New | | | | |

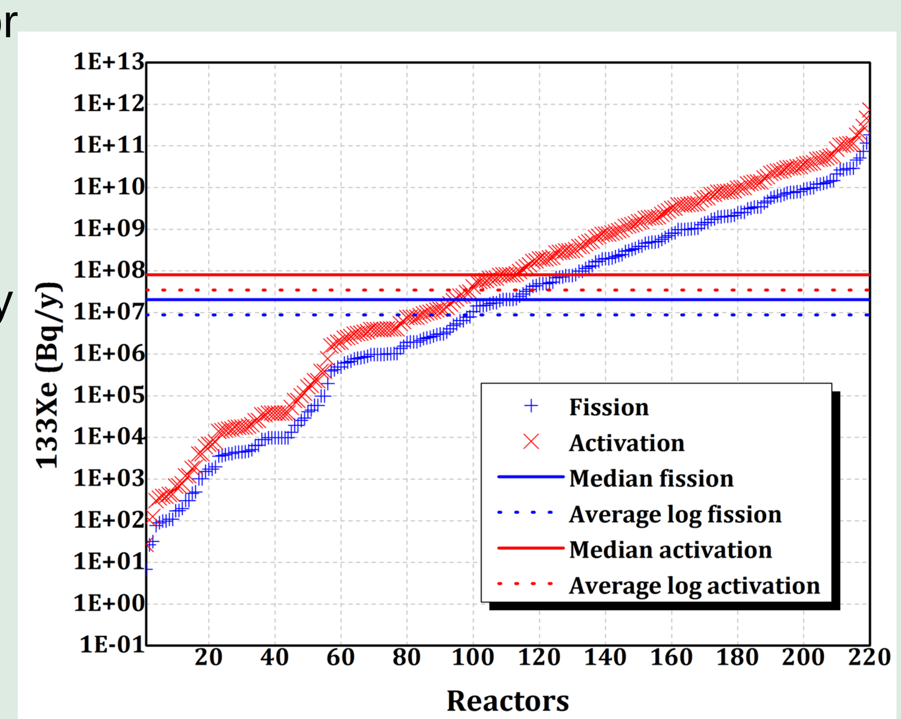
As reported
Partial reports
Best estimate, report calibrated
Best estimate
No estimate available




These histograms show the annual emissions of Xe-133 sorted by size for the old data set and for the new one. Please note that the identity numbers are reshuffled.

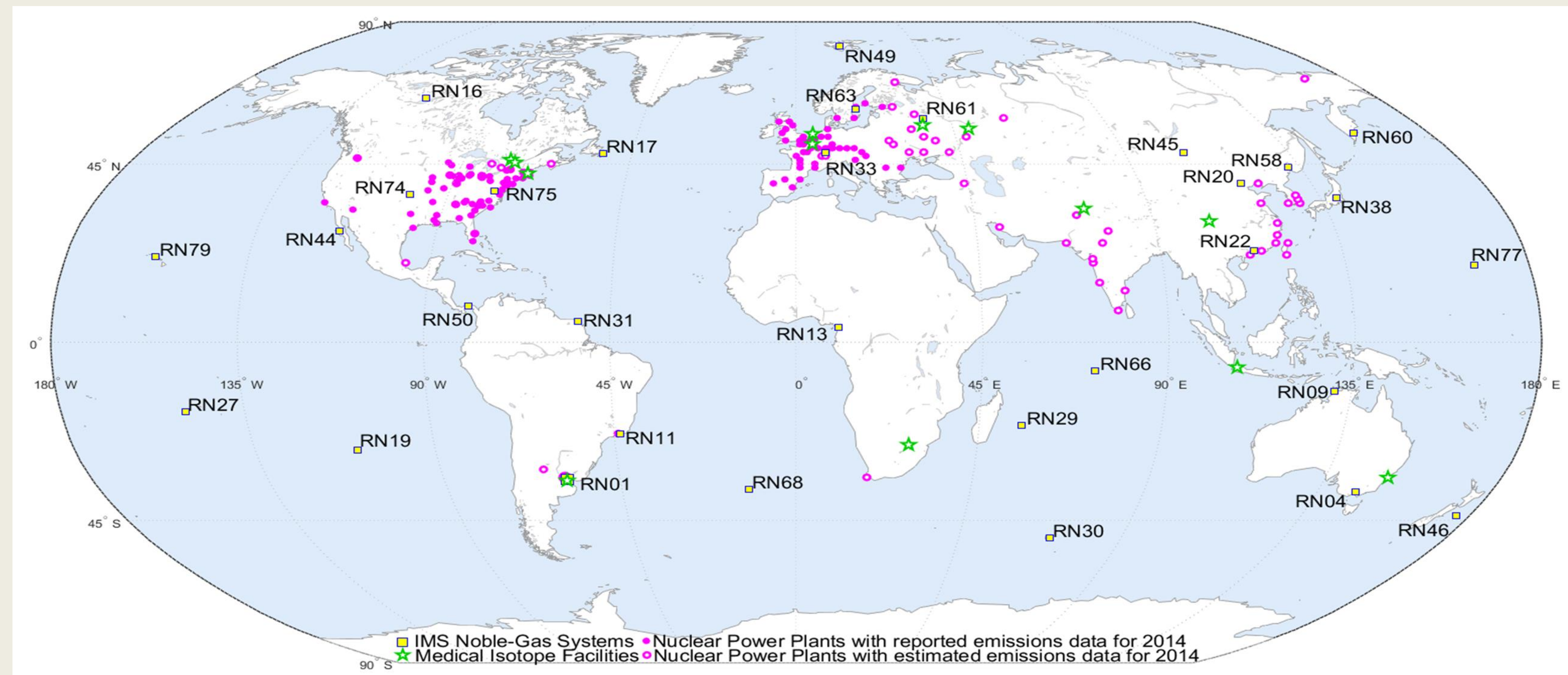
## NUCLEAR RESEARCH REACTORS

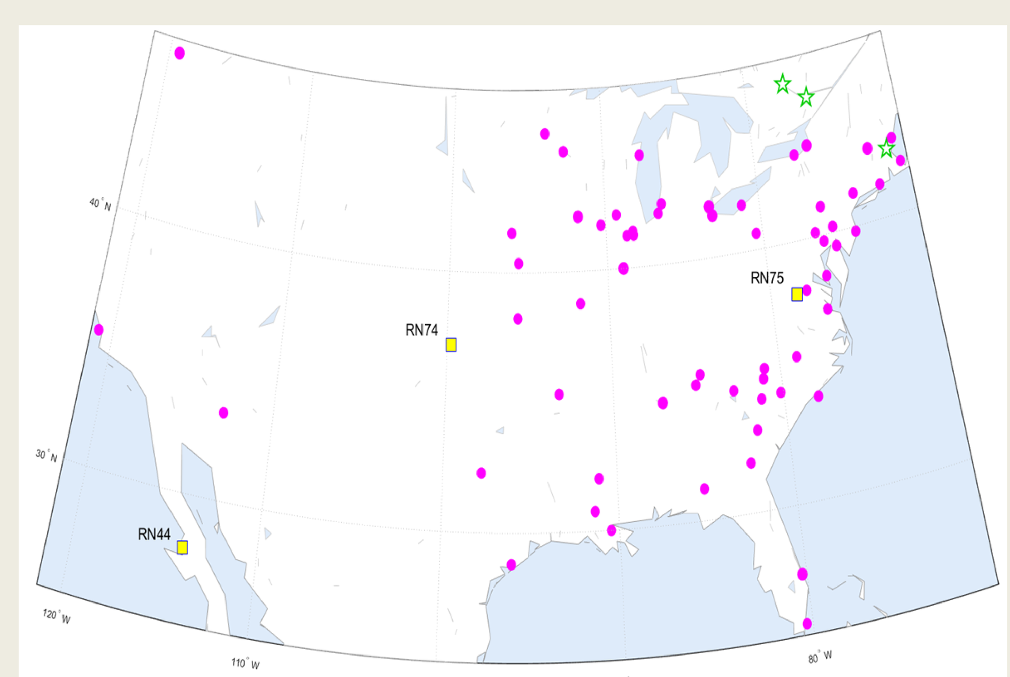
The radioxenon emissions for the global fleet of research reactors is estimated by Kalinowski/Tayyebi (2019). The plot shows their annual Xe-133 emissions ordered by size. 24 NRRs operational in 2014 on the Northern Hemisphere are used for the third ATM Challenge. They have a daily Xe-133 release of more than 1E+07 Bq/d. The strongest source of this type has 3.85E+08 Bq/d.

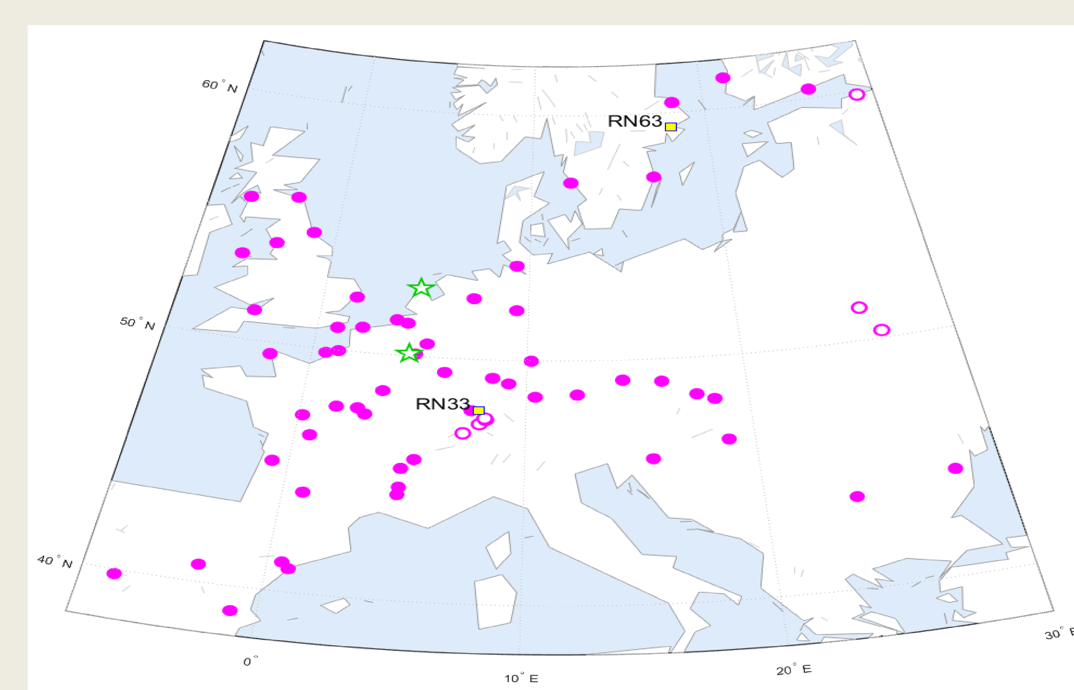


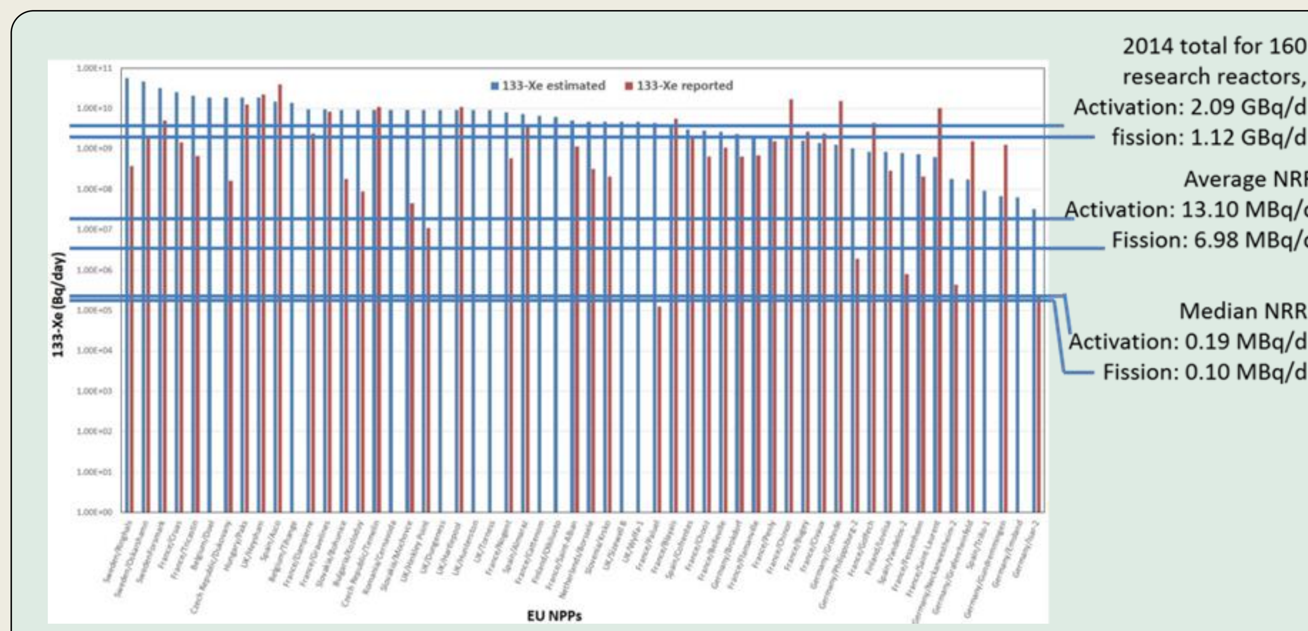

## NUCLEAR POWER PLANTS (NPPs)

**For all source types**, the best estimate of the global emission inventory for the year 2014 was presented by Gueibe et al. (2017). That publication focuses on the year 2014 but only with annual total release values based on peer-reviewed publications. The only information specifically valid for 2014 is the operational status of known sources. In the updated emission inventory presented here the real 2014 emissions with variations over time as reported by the facility operators were used whenever available.
**For NPPs** Kalinowski/Tuma (2009) establishes the best estimate for normal operational releases from NPPs for a generic year. Kalinowski/Halit (2019) are using emission reports for each reactor for which they are available. This is the case for most NPPs in the EU and the USA. These are marked on the below world map with filled circles. In 2014, there were 385 nuclear power plants (NPPs) at 174 sites in operation. Reported data are available from 227 NPPs (59%).








The above blue histogram bars show the Xe-133 emissions of all NPPs in the EU ordered by best estimates according to Kalinowski/Tuma (2009). The red bars are the reported values for 2014 (Kalinowski/Tayyebi, 2019). The horizontal lines apply for NRRs (Kalinowski/Tatlisu, 2019).

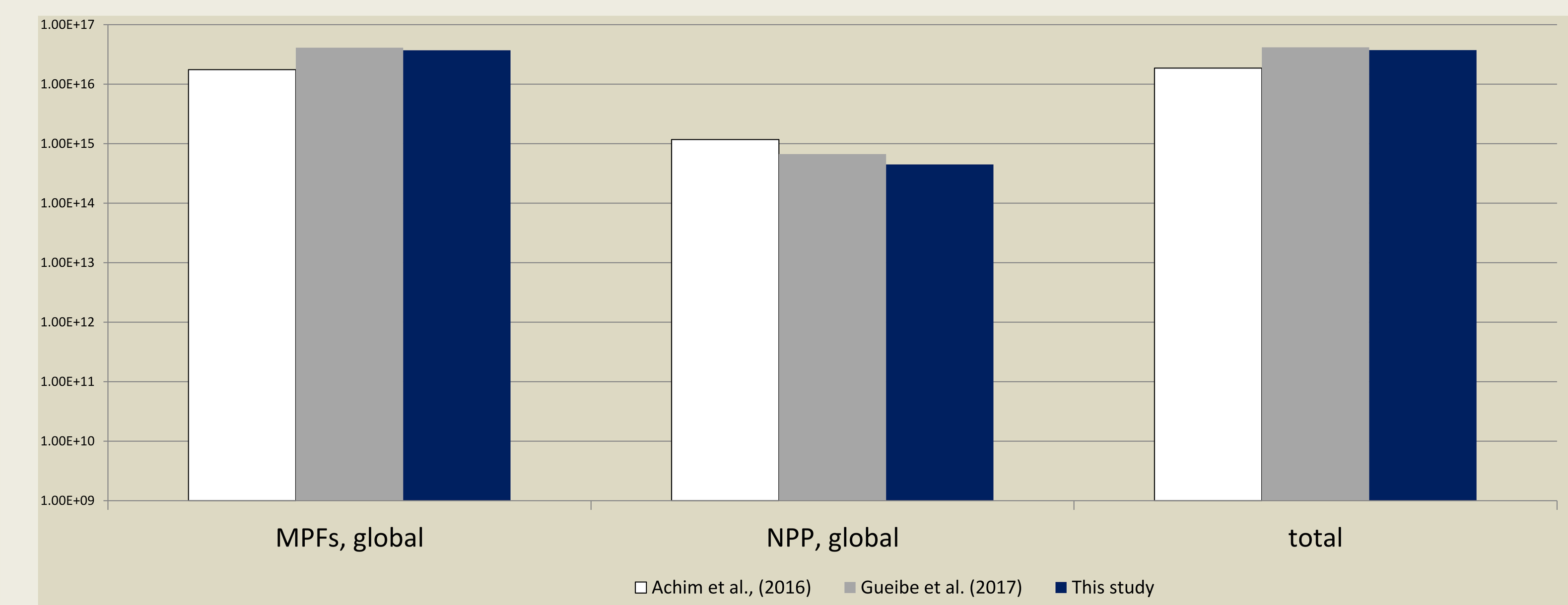
The reported radioxenon emissions for each individual NPP are very different from the best estimate. Some reactors had up to ten times higher emissions but in most cases the release was up to five orders of magnitude lower.

The comparison with NRR releases shows that all NRRs together emit as much as a single NPP does. However, 50% of NRRs emit more than the NPP with the lowest emissions.

## COMPARISON

The update for 2014 made in this study is very close to previous best estimates made by Achim et al. (2016) and by Gueibe et al. (2017).

**MIPFs**: The emission inventory of the MIPFs is very close to the last estimate even though 13 instead of 7 facilities were included here.
**NPPs**: The global emission inventory of NPPs is slightly decreasing but fairly stable. However, for individual NPP sites the estimate is corrected in the 2014 inventory by up to five orders of magnitude.
**NRRs**: This source type is included for the first time. All NRRs together are as strong as a single NPP.




## REFERENCES

**Achim P., Generoso, S., Morin, M., Gross, P., Le Petit, G., & Moulin, C. (2016)** Characterization of Xe-133 global atmospheric background: Implications for the International Monitoring System of the Comprehensive Nuclear-Test-Ban Treaty. Journal of Geophysical Research: Atmospheres, 121(9), 4951-4966. https://doi.org/10.1002/2016JD024872
**Gheddou, A.; Kalinowski, M.; Kusmierczyk-Michulec, J.; Bourguoin. B.:** Progress over 2014 baseline on the match between observations and simulations of radioxenon concentrations at IMS stations. SnT2019, poster T2.4-P46.
**Gueibe, Christophe, Martin B. Kalinowski, Jonathan Baré, Abdelhakim Gheddou, Monika Krysta, and Jolanta Kusmierczyk-Michulec (2017)** Setting the baseline for estimated background observations at IMS systems of four radioxenon isotopes in 2014. Journal of Environmental Radioactivity 178, 297-314. https://doi.org/10.1016/j.jenvrad.2017.09.007
**Kalinowski, M.B.; Tuma, M.P. (2009)** Global radioxenon emission inventory based on nuclear power reactor reports. Journal of Environmental Radioactivity 100, 58-70. http://dx.doi.org/10.1016/j.jenvrad.2008.10.015
**Kalinowski, M.B.; Grosch, M.; Hebel, S. (2014)** Global Xenon-133 Emission Inventory Caused by Medical Isotope Production and Derived from the Worldwide Technetium-99m Demand. Pure and Applied Geophysics: Volume 171, Issue 3, 707-716. https://doi.org/10.1007/s00024-013-0687-5
**Kalinowski, M.B.; Tatlisu, H. (2019)** Global radioxenon emission inventory for 2014 by normal operational releases from nuclear power plants (NPPs) and medical isotope production facilities (MIPFs). SnT2019 poster T2.4-P27.
**Kalinowski, M.B.; Tayyebi, P., S. Biegalski, M. Lechermann, and A. Ringbom** (2019) Contribution of All Nuclear Research Reactors to the Global Radioxenon Emission Inventory. SnT2019 presentationT2.4-04.
**Maurer, Christian et al. (2018)** International challenge to model the long-range transport of radioxenon released from medical isotope production to six Comprehensive Nuclear-Test-Ban Treaty monitoring stations. Journal of Environmental Radioactivity https://doi.org/10.1016/j.jenvrad.2018.01.030

## DATA SHARING

These data are available for participants to the 3rd ATM Challenge via vDEC http://www.ctbto.org/specials/vdec.
Contact: vdec@ctbto.org