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Progress over 2014 baseline on the match between observations and simulations of radioxenon concentrations at IMS stations

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Introduction

Normal operational releases of radioxenon make the discrimination between radioxenon detections from civil nuclear applications and from nuclear testing a very complex task. The objective on the short to medium term is to develop algorithms and tools that facilitate the understanding of the background. The longer-term vision is to eventually develop robust methodologies for determining to what extent radioxenon detections at International Monitoring System (IMS) stations can be explained based on the impact of civil sources. The 2014 baseline is updated in two ways. On one hand, the radioxenon emission inventory has been updated. On the other hand, observed radioxenon activity concentrations at the IMS noble gas sites have been further reviewed. The update involves offline reprocessing of the spectral data using a new NCC configuration. The potential xenon contribution from civil sources was estimated using the output of Atmospheric Transport Modelling (ATM) so called source-receptor-sensitivity (SRS) fields. The presentation compiles achieved results for simulated concentration estimates and observations at IMS stations. The statistical analysis of simulated vs. observed data is being repeated and compared with the 2014 baseline that was set in a previously published study (Gueibe et al., 2017).

Considered locations

The study considers the 25 IMS certified systems from SAUNA and SPALAX technologies.

Updated observation results

The standard NCC method as implemented in the IDC software conditionally corrects interference from radon, Xe-133 key ROIs into lower gamma energy ROIs. The correction is performed only if the counts exceed respective critical level (LC). It was demonstrated that this leads to high rate of false positives, namely for Xe-131m and Xe-133m.

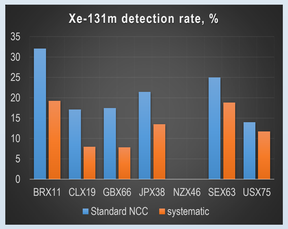
In order to reduce the rate of false positives, spectra data from SAUNA systems were reprocessed in offline mode, using an alternative configuration of NCC method which systematically corrects ROI counts for interferences.

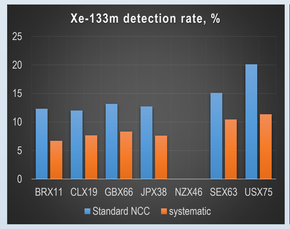
Results comparison

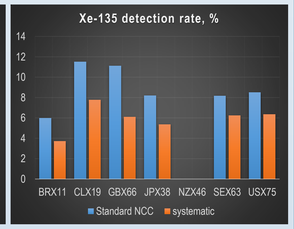
Analysis results based on alternative NCC configuration were compared to standard NCC results. Used data correspond to SAUNA spectra with good sample metrics.

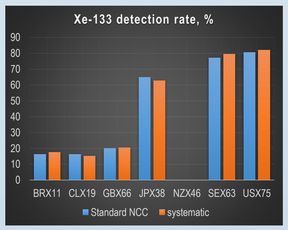
Implication on detection rate

The following Figures compare detection rates based on both analysis configuration for the four xenon isotopes at a subset of 6 IMS stations. Because of averred calibration issues, the results from NZX46 were finally disregarded.







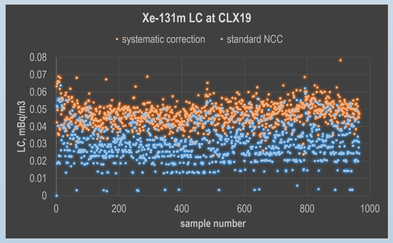


For Xe-131m, Xe-133m and Xe-135, the new configuration demonstrates a clear reduction of false positives compared to the standard NCC. Achieved values are closer to the theoretical level of 5% for stations with clean background.

The rate of Xe-133 detections is not affected in comparison to initial results because these correspond to real detections.

Implication on LC

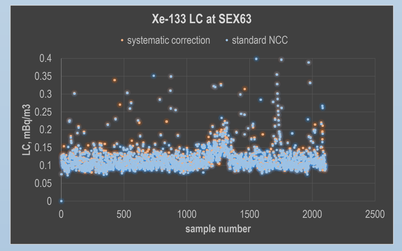
Typical cases are illustrated by the following Figures.



(Xe-131m is unlikely to be detected at CLX19)

Median(LC), mBq/m3:
- Standard NCC: 0.03
- Systematic correction: 0.05

This contributes to lowering down the detection rate of “systematic correction” compared to standard NCC.



(Xe-133 is likely to be detected at SEX63)

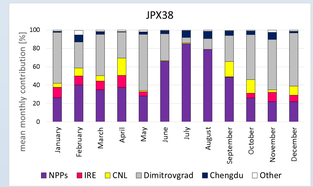
Median(LC) , mBq/m3:
- Standard NCC: 0.11
- Systematic correction: 0.11

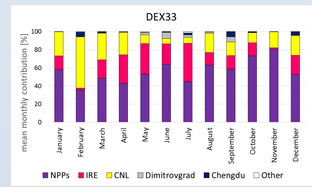
This explains why “systematic correction” produces very similar detection rate compared to standard NCC.

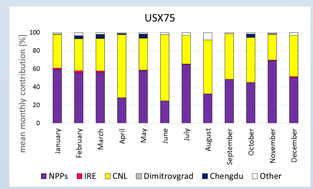
Updated simulated impact

To estimate the contribution from the major Medical Isotope Production Facilities (MIPFs) and from NPPs which were operational in 2014 (IAEA, 2015), the ATM results in the backward mode were used. The daily values of Xe-133 released from facilities are the best estimate from literature. In case of IRE (Belgium), CNL (Canada), and ANSTO (Australia) the real daily emission values were used. Since the number of NPPs is very large, only the cumulative effect is indicated and labelled as NPPs.

Examples on obtained results in terms of contribution to the impact on IMS stations across the year 2014 are shown in the following Figures.







Summary

Observed radioxenon activity concentrations at SAUNA based IMS certified noble gas sites have been revisited by offline reprocessing of the spectral data using a new NCC configuration.

The results show substantial improvement on the detection rates of three isotopes: Xe-131m, Xe-133m and Xe-135 while keeping Xe-133 results unchanged.

On the other hand, enhanced results of simulated impact on IMS certified noble gas stations are obtained by using updated inventory on emissions from civil sources.

The results are currently under further analysis for updating the 2014 baseline of radioxeon at IMS certified noble gas stations.

References

- Gueibe C., Kalinowski M., Bare J., Gheddou A., Krysta M ., Kusmierczyk-Michulec J., 2017. Setting the baseline for estimated background observations at IMS systems of four radioxenon isotopes in 2014. Journal of Environmental Radioactivity 178-179 (2017) 297-314.
- IAEA, 2015. Power Reactor Information System. International Atomic Energy Agency.
- Kalinowski M. (T2.4-P27) Global radioxenon emission inventory for 2014 by normal operational releases from Nuclear Power Plants and Medical Isotope Production Facilities.