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Automatic radioxenon data validation for increased measurement reliability

Jennifer Mendez, Yolanda Olivera, Brian Schrom

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Pacific Northwest
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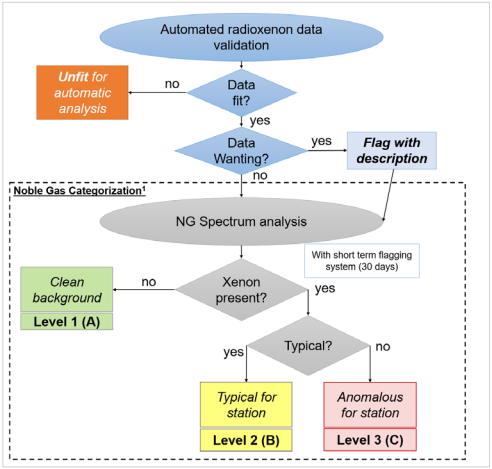
A ***reliability*** metric may help an analyst quickly prioritize and review radionuclide spectra. This same metric may be a prerequisite for robust automatic consumption of automatically generated concentration data. This work is developing a metric suitable for exploration and evaluation of its applicability for radioxenon data.



Valid data is fit for its intended purpose. In the case of radioxenon spectra, the intended purpose is activity concentration analysis. Validation checks assign a reliability label to each measurement indicating whether results from automated analysis would be expected to be reliable. Automated analysis of "Unfit" measurements produces unreliable results.

Reliability Labels	Meaning
Fit	Fit for automated analysis
Wanting	Lacking in some way. Proceed with automated analysis, but include flag
Unfit	Unfit for automated analysis

How to detect reliability?

The following metadata parameters are compared against fitness limits.

Range Checks:

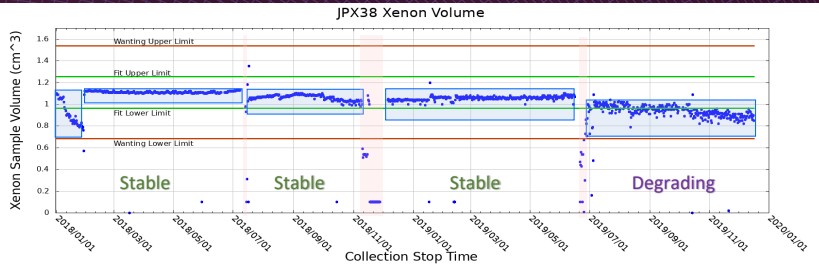
- Xenon volume
- Detector/gas/sample count real time
- Air volume
- Processing time elapsed
- Collection time elapsed

Data validation checks:

- QC source presence/absence
- Measurement set cross field validation (e.g., gas background cannot occur after sample)

Fitness limits are largely based on standard deviations calculated from acceptable operation station history.

If a validation check exceeds a fit limit, the reliability index will be "wanting" which will include a text description of the error. If a validation check exceeds a wanting limit, the reliability index for the whole measurement will be deemed "unfit" for further automatic analysis.



Apply domain knowledge

Some metadata variables are easily bounded by standard deviations with few outliers. However, some, such as xenon volume, are heavily impacted by system performance. Setting fitness limits is done here with data containing varied system performance. Consider the five blue rectangles on the graph above. Fitness limits developed on one of these time periods alone would produce different limits. Typically, control limits are not determined using out of control data. However, we are not monitoring station health, but instead for reliable measurement data. Therefore, these fitness limits include the variability.

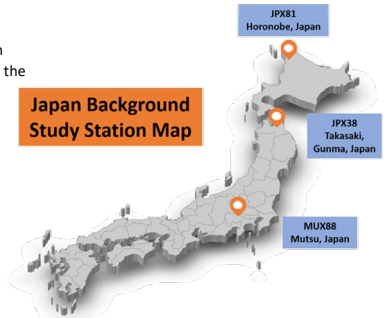
Flag system degradation

Xenon volume is a major indicator of sample reliability. If the xenon volume falls outside of fitness limits, there is a good chance the measurement is unreliable. However, even when the xenon volume trends down as in the degrading period above, reliable data is still generated. Using two fitness limits acknowledges the data can still generate useful automatic analysis results while flagging a measurement as "Wanting" for drifting outside the ideal "Fit" bounds.

Impact on Categorization

These validation checks were exercised on data from three SAUNA II stations participating in the current Japan Background Study which started in 2018. The table below summarizes the results of these radioxenon data validation checks and the categorization according to the Noble Gas Categorization Scheme of 3,599 measurement sets from those stations. This reliability metric would be complementary information to an automatic radionuclide report (ARR). It could help prioritize analysis efforts and build higher confidence that analysis results are correct.

	Fit	Wanting	Unfit	Total
Category A	1750	452	528	2730
Category B	599	87	11	697
Category C	131	23	**18**	172
Total	2480	562	557	3599



References:
[1] M. Nikkinen, U. Stoehlker, A. Gheddou, and M. Verpelli. Noble gas categorisation scheme. WGB 36 Presentation, 2011.

Acknowledgements:
This research was funded by the National Nuclear Security Administration, Defense Nuclear Nonproliferation Research and Development (NNSA DNN R&D). The authors acknowledge important interdisciplinary collaboration with scientists and engineers from LANL, LLNL, MSTS, PNNL, and SNL. The views expressed here do not necessarily reflect the views of the United States Government, the United States Department of Energy, the National Nuclear Security Administration or Pacific Northwest National Laboratory.

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ABSTRACT

Reliability metric

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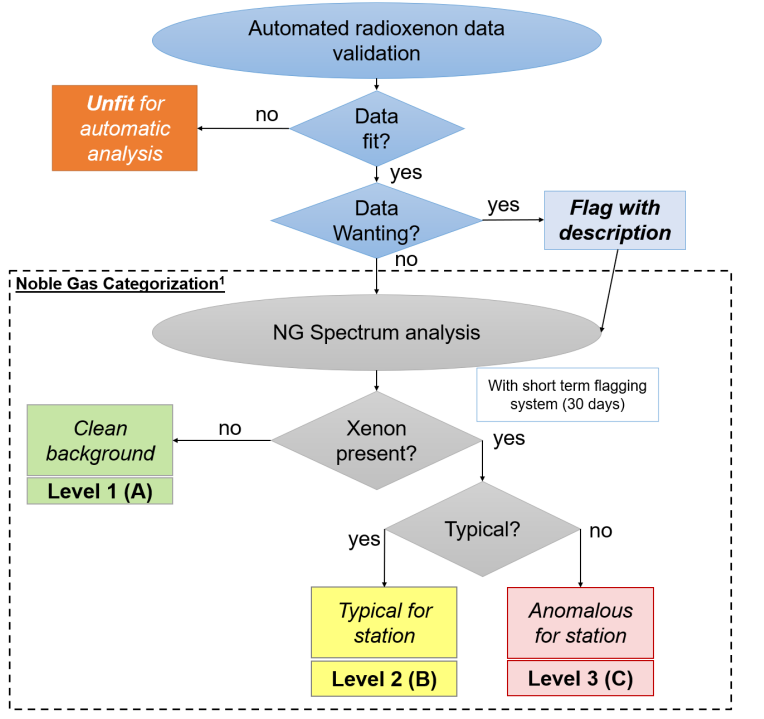

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INTRODUCTION

Reliability labels

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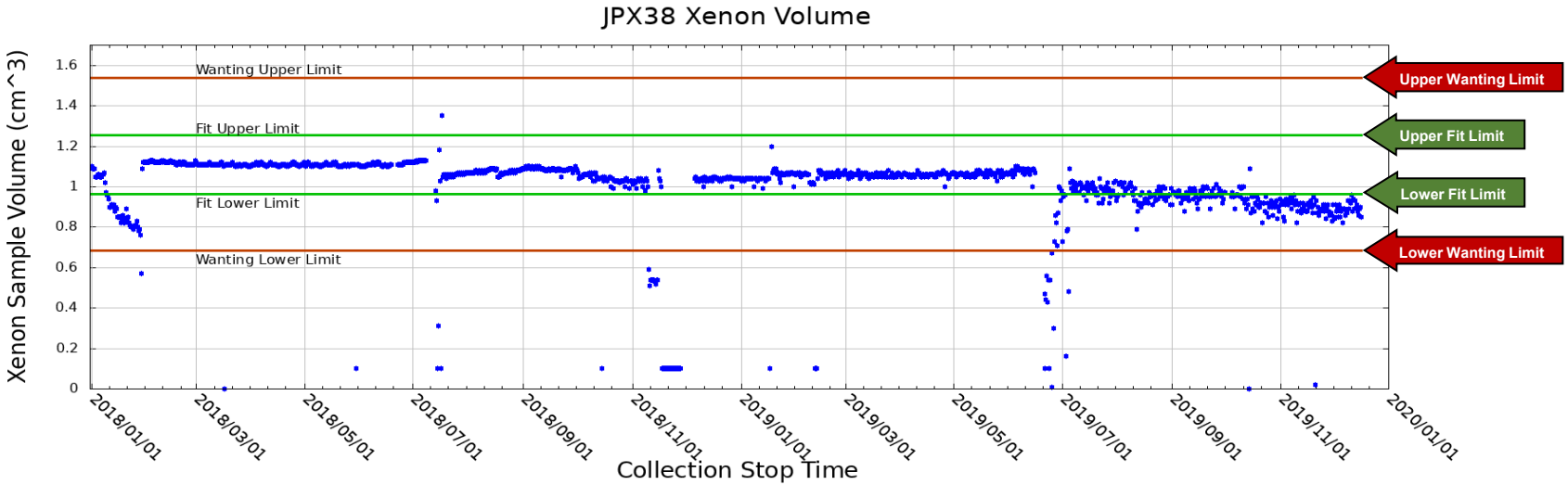

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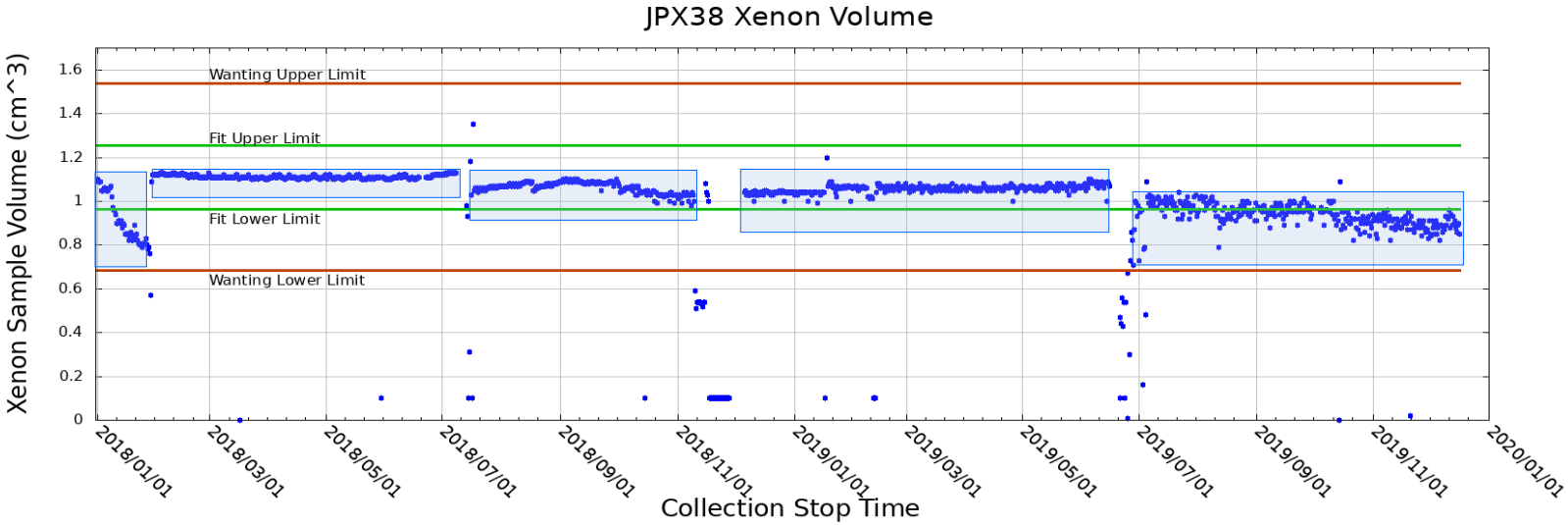

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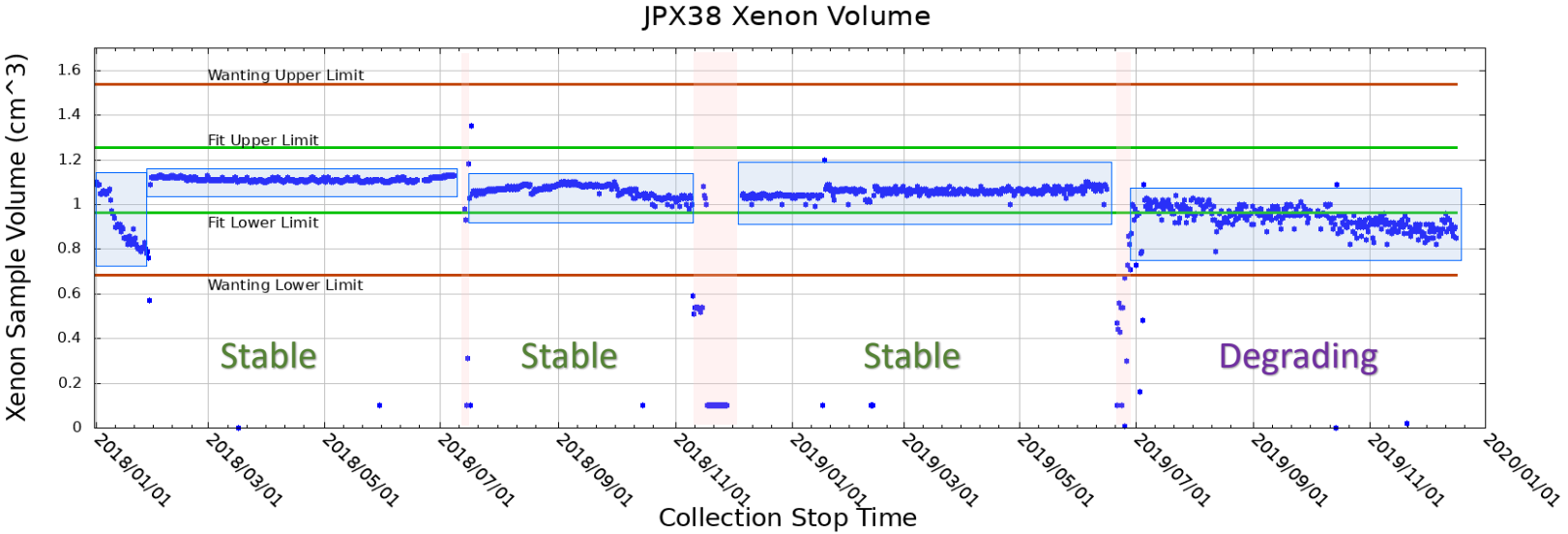

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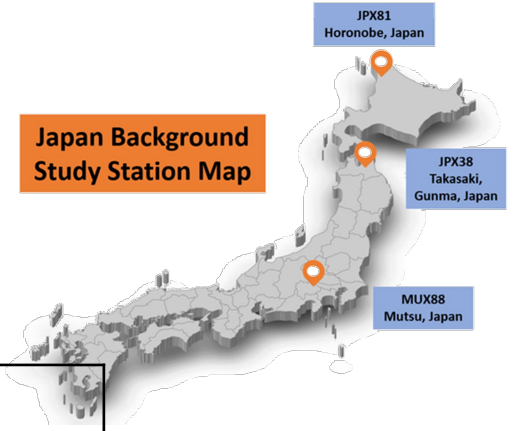

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