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Quantifying the Potential of Argon Detection Capabilities for Nuclear Explosion Monitoring

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INTRODUCTION

This work quantifies the capabilities of a hypothetical ^{37}Ar detection network for underground nuclear explosion (UNE) monitoring and shows that a ^{37}Ar detection network could be a useful addition to the current radioxenon detection network.

METHODS/DATA

A series of HYSPLIT models created for a representative release indicative of a UNE were adapted to calculate dilution factors at specified radioactive noble gas detection stations. The dilution factor was multiplied by the release activity of ^{37}Ar and a decay factor for each point in time to get an expected concentration of ^{37}Ar at each station for each simulation start date and sample collection date.

START

RESULTS

With a sufficiently low detection limit, a network of 37Ar detectors would have a high probability of detecting 37Ar produced from a UNE. Additionally, 37Ar can be detected in coincidence with radioxenon isotopes helping to increase confidence in signature analysis.

CONCLUSION

This work demonstrates the utility of a possible ^{37}Ar signature for the purposes of nuclear explosion monitoring. Coincidence detection with xenon isotopes could help increase confidence in signature analysis.

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Introduction

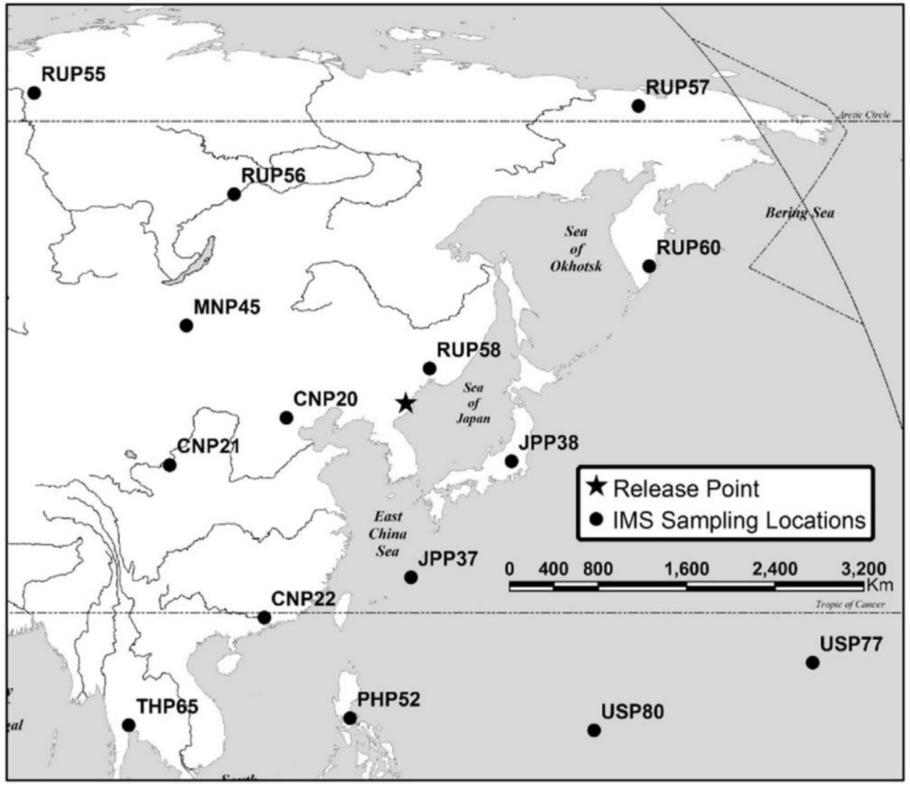
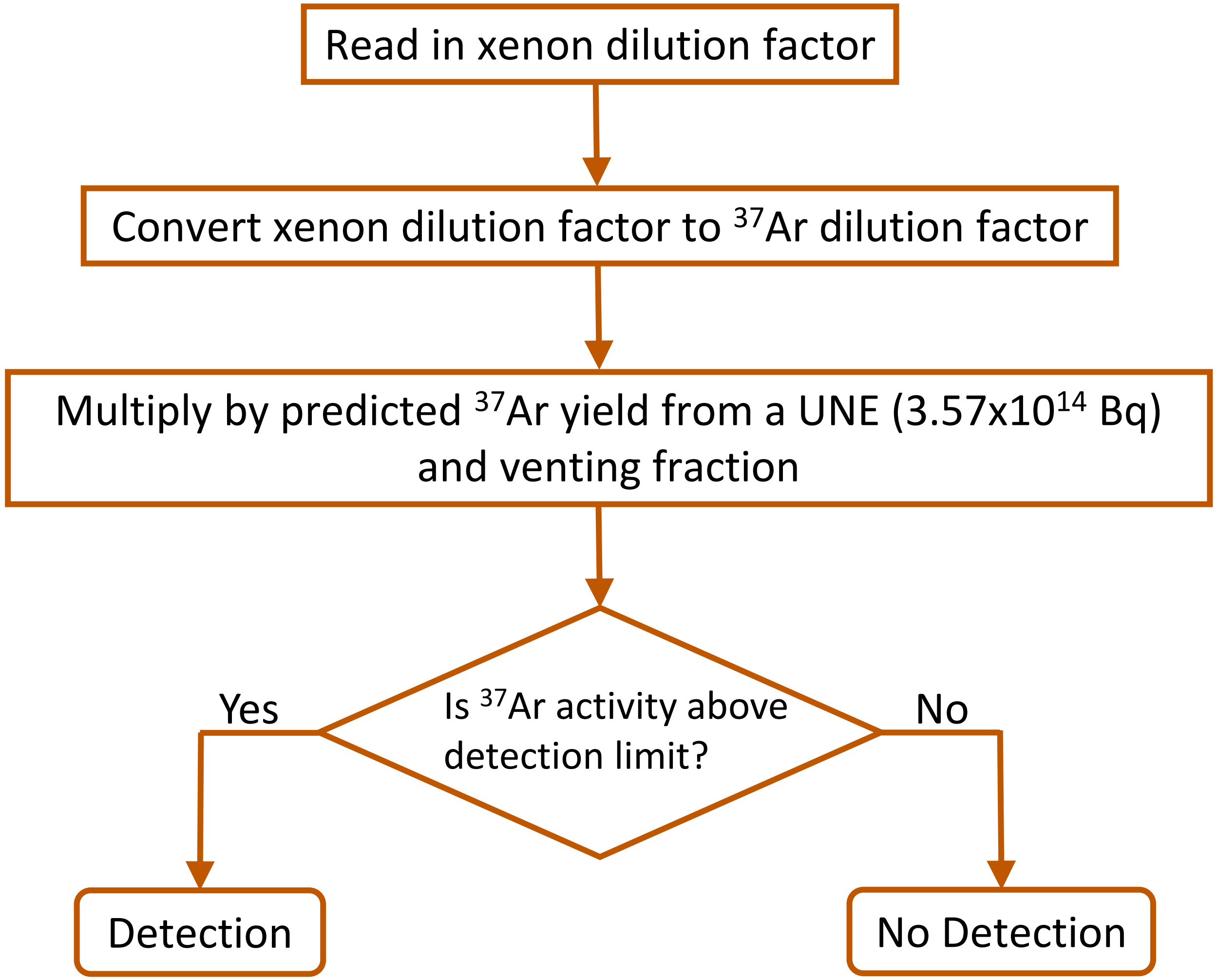


Fig 1. Map showing release point for the hypothetical release and radionuclide sampling locations. [1]

^{37}Ar is primarily produced in a UNE through the neutron activation of ^{40}Ca in soil and rock. High probability of occurrence of the $^{40}Ca(n,\alpha)^{37}Ar$ reaction makes it a worthwhile consideration as a signature of interest for UNE detection [2]. ^{37}Ar has a 35-day half-life, which is long enough for meaningful collection and analysis to take place after an explosion. Using ^{37}Ar as a detection signature in conjunction with the four xenon isotopes in atmospheric measurements could be especially useful in cases where an elevated xenon background results in significantly altered isotopic ratios.

Methods



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Results

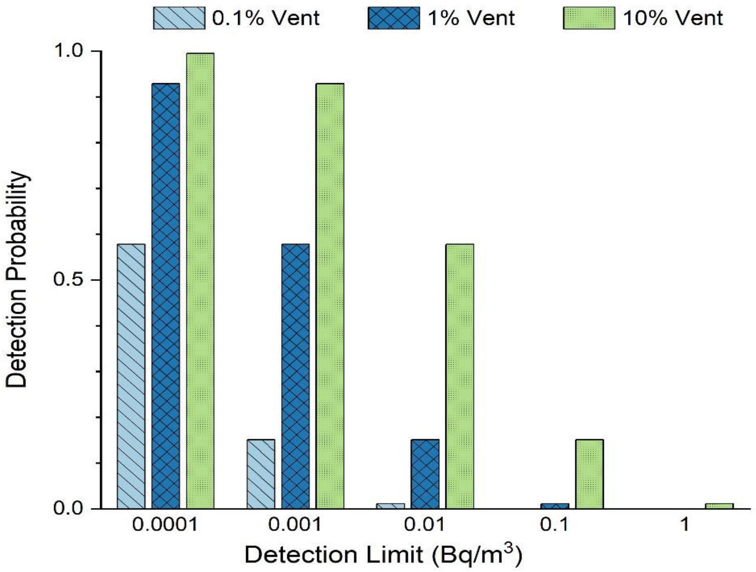

Fig 2. Probability that a release is detected in one or more samples.

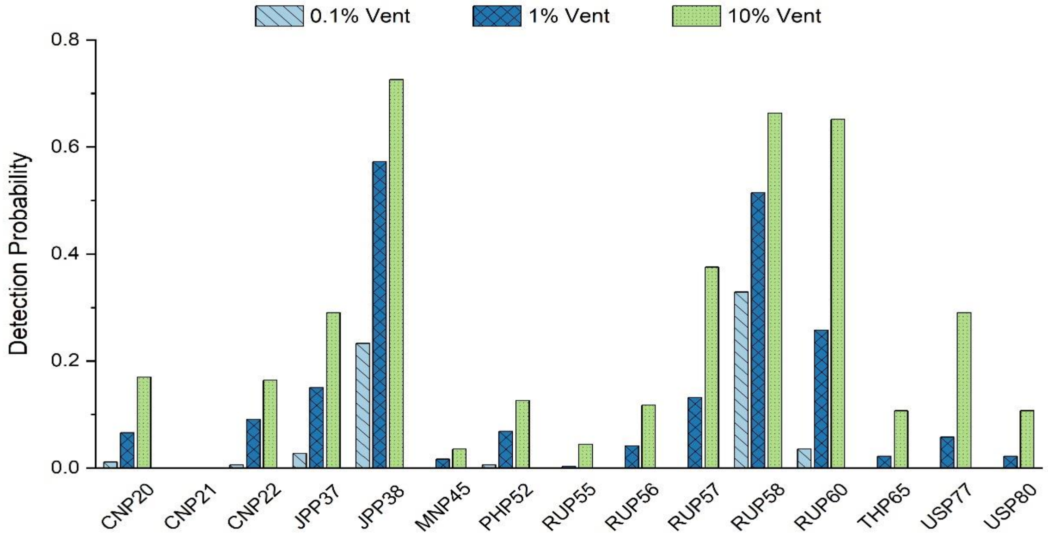

Fig 3. Probability that a release is detected in one or more samples by sampling location.

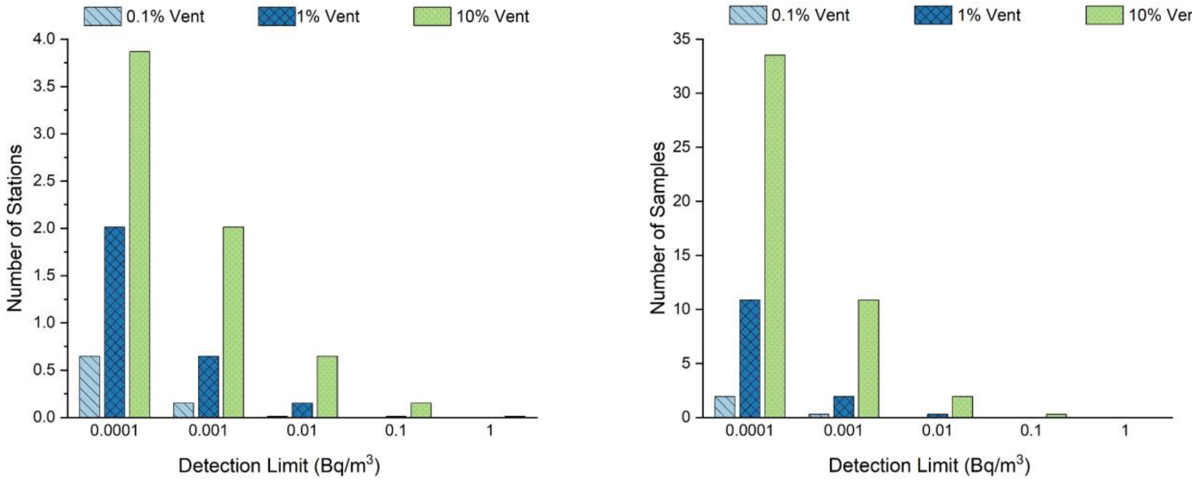

Fig 4. Average number of stations detecting each release and average number of samples with a detectable concentration.

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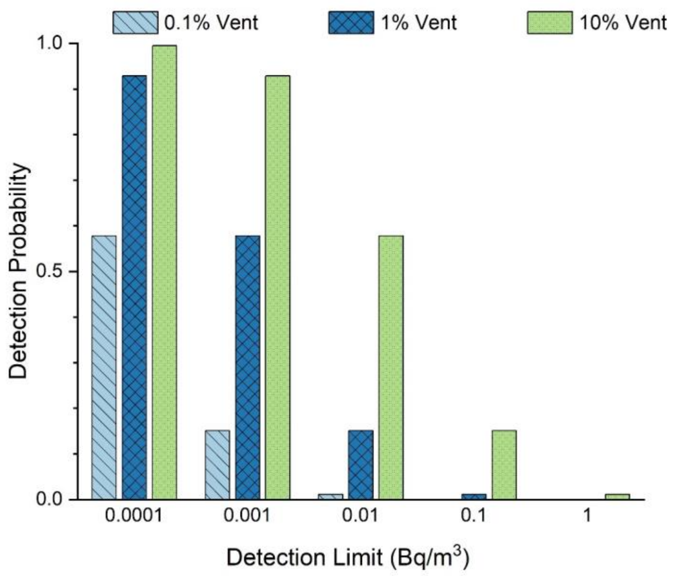
Conclusion

This study demonstrates the utility of ^{37}Ar as an additional signature for nuclear explosion monitoring. With a sufficiently low detection limit, a network of ^{37}Ar detectors would have a high probability of detecting ^{37}Ar produced from a UNE. Additionally, ^{37}Ar can be detected in coincidence with radioxenon isotopes as shown in the detection probability, helping to increase confidence in signature analysis.



Recommendations:

1. A monitoring system for ^{37}Ar should have a detection limit of 1 mBq/m^3 or lower to be an equivalent signature to any of the xenon systems currents in use.

2. Attempts should be made to lower the detection limit to 0.1 mBq/m^3 system, which could increase the detection probability. Opportunities include counting samples longer (more Ar detectors), reducing backgrounds, and improved separations chemistry (more Ar sampled).

3. More robust measurements of current ^{37}Ar background and good characterization of ^{37}Ar sources are essential to be able to set a more accurate detection limit for a ^{37}Ar system.

Acknowledgments and References

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