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Applying Radioxenon Isotopic Ratios for Nuclear Explosion Monitoring: Determining the Origin Time

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INTRODUCTION AND MAIN RESULTS

This study is to estimate the origin time of nuclear explosions using radioxenon isotopic ratios from IMS stations.
Decay modeling with violin plots from Xe-135/Xe133 and Xe-131m/Xe-133 improves accuracy and detects anomalies.
Results agree with seismic data, confirming the method's reliability.

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Introduction

Estimating the origin time of a nuclear explosion is key for verifying compliance with the CTBT.

Radioxenon isotopes (^{131}mXe, ^{133}Xe, ^{133}mXe, ^{135}Xe) are produced during fission and detected by the IMS network.

Their isotopic ratios change over time because of radioactive decay, revealing the time since detonation.

The Xe-135/Xe-133 ratio decreases steadily due to the shorter half-life of Xe-135.

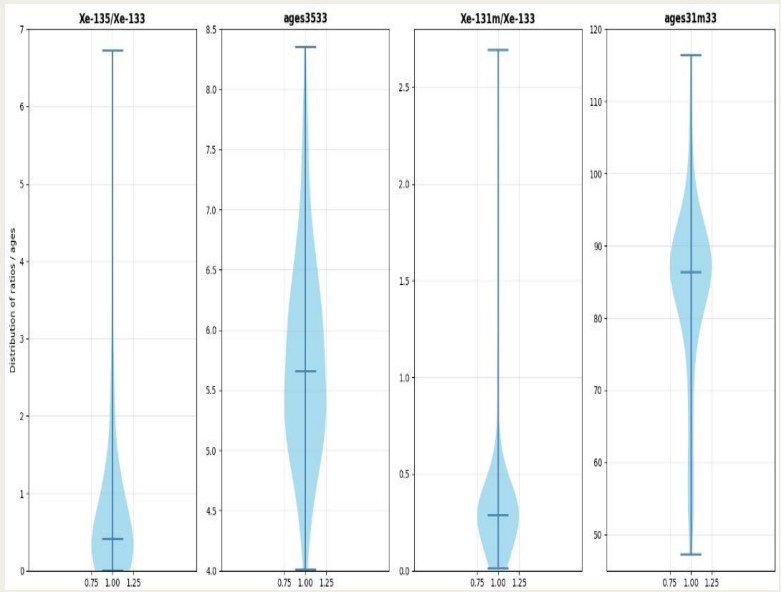
The Xe-131m/Xe-133 ratio provides an additional time marker.
Decay models applied to these ratios, combined with violin plots, improve origin time estimates.
This approach helps detect anomalies and is validated by sismic data .

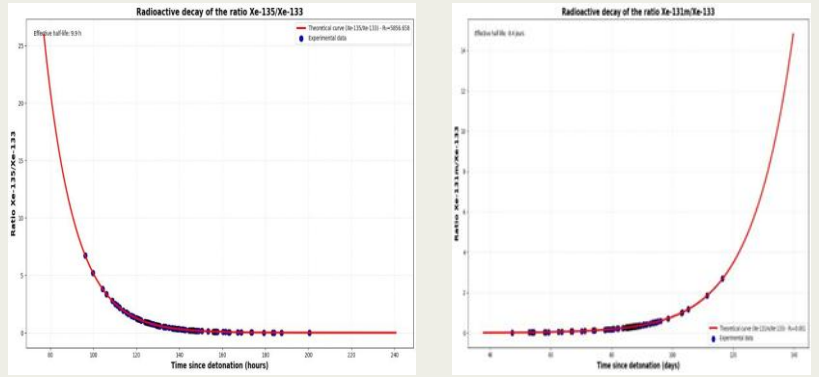
Methods/Data

Use of real IMS network data from the DPRK nuclear tests in 2013.
Simulation of isotopic ratios Xe-135/Xe-133 and Xe-131m/Xe-133.
Radioactive decay modeling to back-calculate the elapsed time since detonation
Statistical validation using violon plots to show median, spread and detect outliers.
Cross-validation with seismic data

Results/Conclusion

Results





Radioactive decay curves

Conclusion

violon plots show consistent median ages across stations with some outliers.
Combining decay modeling and statistical visualization refines the estimation of origin time.
Results align with independent seismic data, confirming the method's reliability.
Remaining challenges include modeling atmospheric transport and station network coverage.