

Impact of Nuisance Background on Source Location

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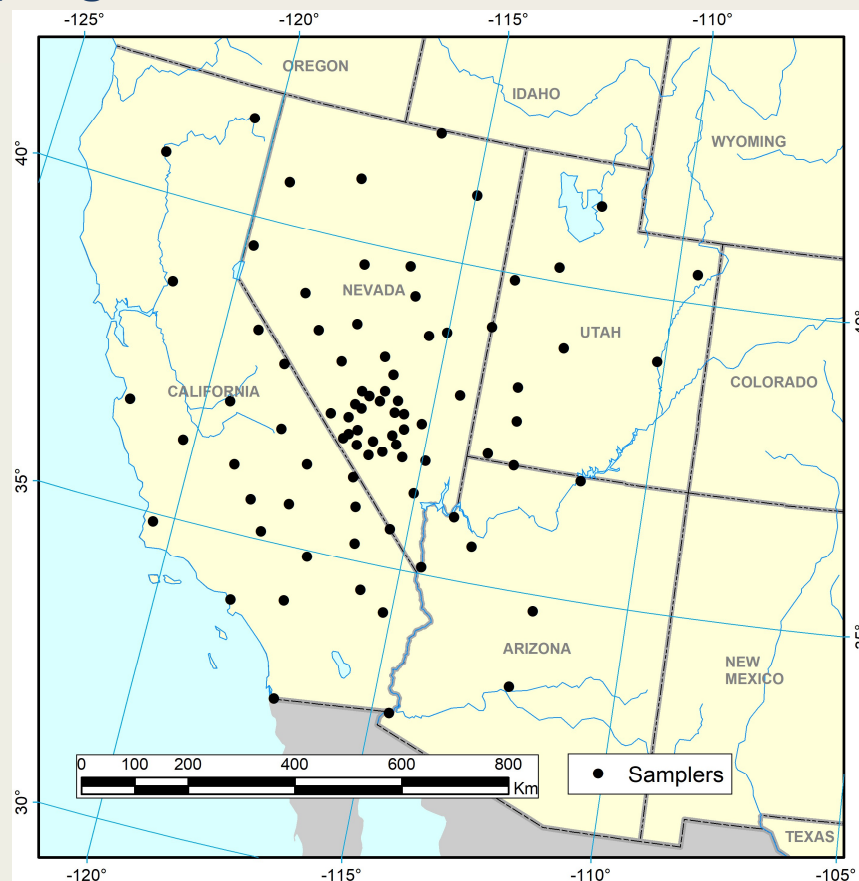
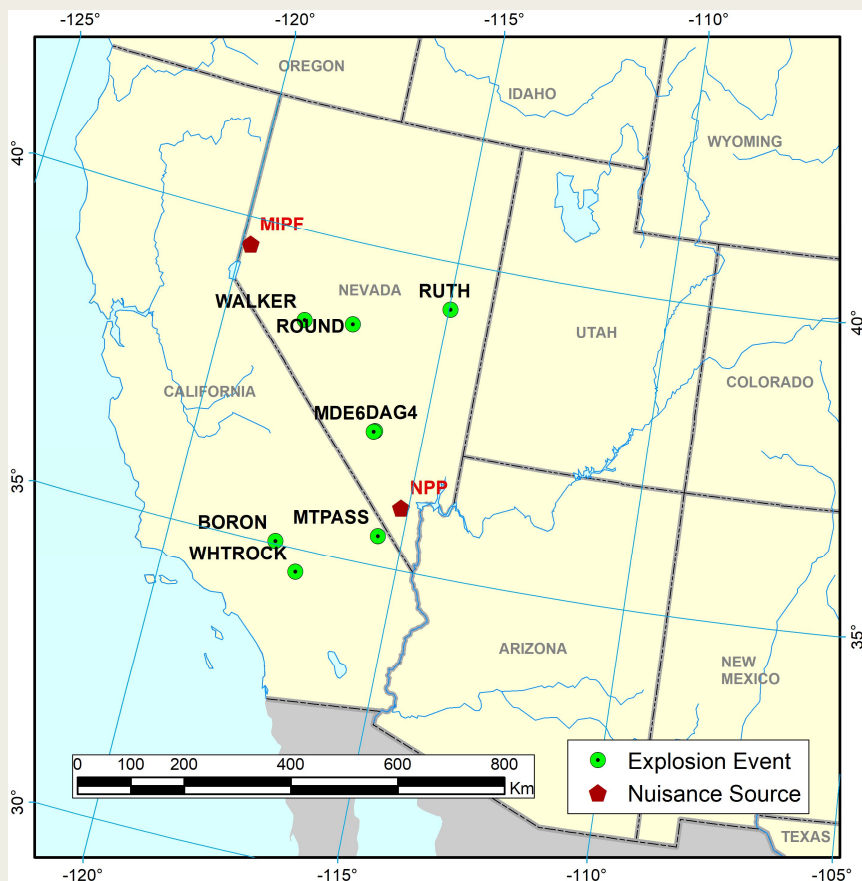
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Motivation

- Most source-term algorithms for atmospheric releases assume there is no influence from nuisance sources
- Industrial sources result in a world-wide background of xenon isotopes that are also useful for detecting nuclear explosions
- A source-location algorithm has been developed that explicitly accounts for nuisance sources
- This work evaluates algorithm performance using a data set with 384 synthetic release events containing ^{133}Xe
 - Can we identify a small release of ^{133}Xe in the presence of background sources?
 - Is there a threshold below which the release is masked by the nuisance sources?

Release and Sampling Locations

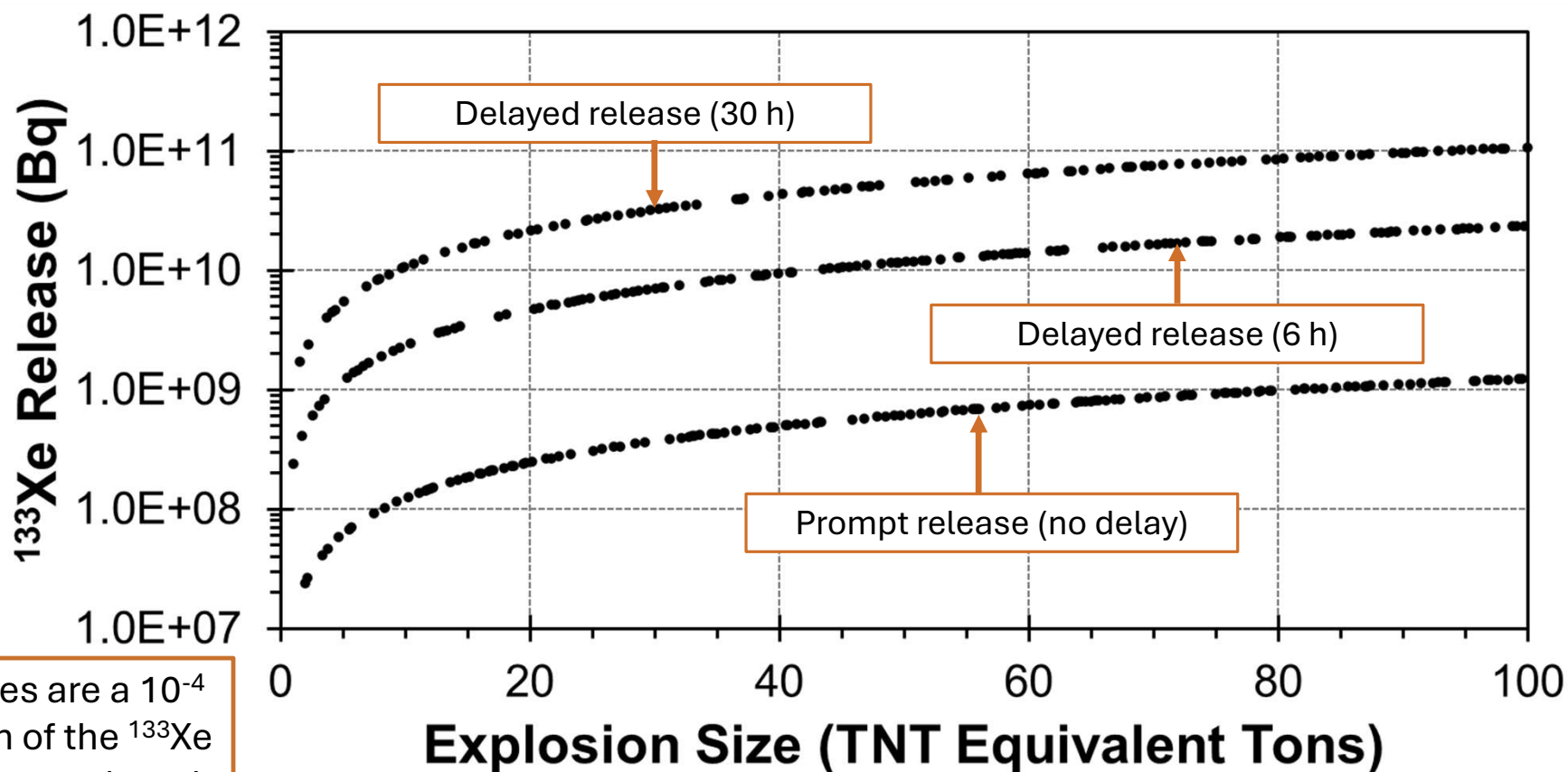


Sampler Characteristics: Brander, S., Baur, S., et al., 2022. *J. Environ. Radioact.* doi:10.1016/j.jenvrad.2022.107034

Release Setting

- 384 synthetic “explosion” release cases
- Two nuisance sources with continuous releases
 - Nuclear power plant (NPP): 10^{10} Bq per day
 - Medical isotope production facility (MIPF): 10^{10} Bq per day
- Atmospheric conditions
 - Use 4 ten-day periods spaced over 18 months (summer and winter)
- Sample concentrations developed using Hysplit based on high resolution WRF runs (900 m spatial resolution, 15 minute outputs) in time-forward mode
- Source-term estimation done using Hysplit and NOAA’s High Resolution Rapid Refresh (HRRR) meteorological data (3 km spatial resolution, 1 hour outputs) in time-reversed mode

Releases of ^{133}Xe from Fission Events



Releases are a 10^{-4} fraction of the ^{133}Xe that was produced.

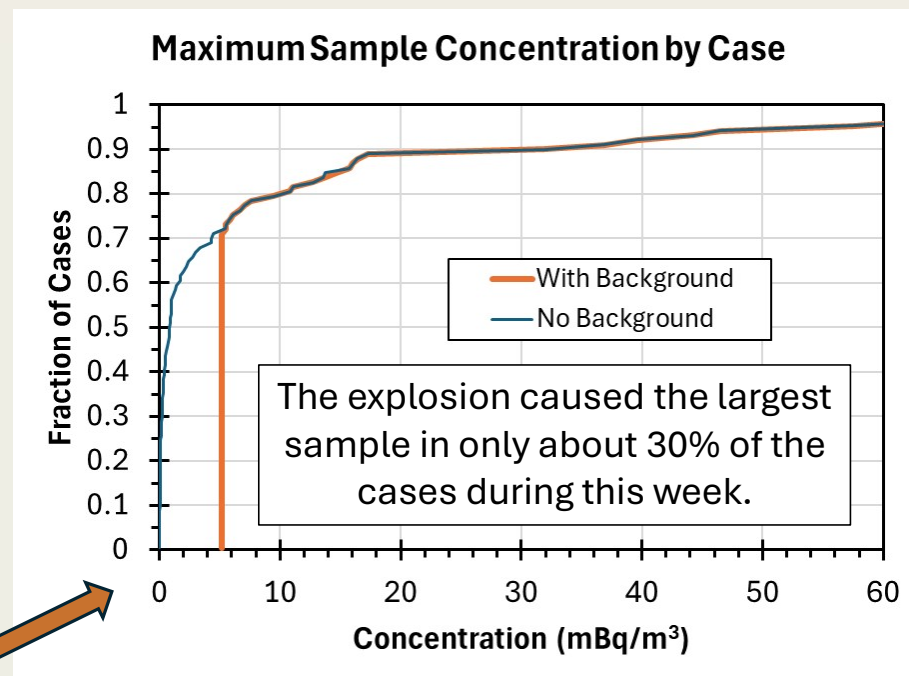
Estimation Model Overview

- Uses a Bayesian framework
- Can estimate releases from two nuisance facilities
 - Known locations
 - Unknown release rates (allowed to change every 3 h)
- Searches for a single release event with unknown release time, duration, location, and magnitude
- Use samples spanning about a week in time

Eslinger, P.W., J.M. Mendez, and B.T. Schrom. 2019. "Source Term Estimation in the Presence of Nuisance Signals." *J Environ Radioact* 203:220-225. doi:10.1016/j.jenvrad.2019.03.022

Comments on Samples (^{133}Xe)

- Explosion emissions (no background)
 - 384 release cases (84 samplers)
 - 254 cases can be estimated (have detections)
 - 7 cases with all zero concentrations
 - 123 cases with all concentrations less than MDC
 - 40 cases with 1 detection
 - 214 cases with 2 or more detections
- Combined with background emissions
 - All 384 cases can be estimated
 - 123 of the cases have an “explosion” term that is greater than 0 but less than the MDC
 - Nuisance sources contribute from 5 to 28 mBq/m³ to maximum samples (depending on the week)



Maximum sample concentrations for a one-week time period (96 cases)

- Use samples for an entire week in the estimation
- All release cases are superimposed on the same background (for that time period)
- The nuisance sources dominate the sample concentrations for about 70% of the cases

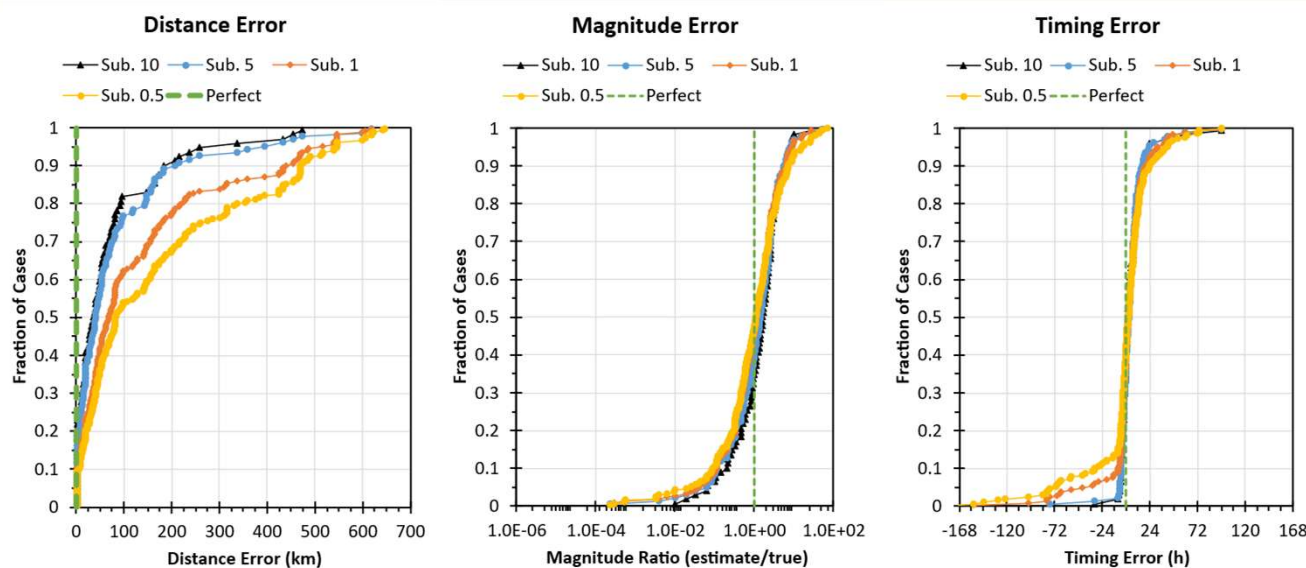
When do nuisance sources mask the release from a short-duration explosion?

Results

Subset the release cases so the explosion causes increases at least one ^{133}Xe sample by:

- 0.5 mBq/m³ : 226 cases
- 1.0 mBq/m³ : 195 cases
- 5.0 mBq/m³ : 114 cases
- 10 mBq/m³ : 85 cases

The major source of estimation error is using one atmospheric model to generate sample concentrations (forward-time runs) and a different model in the source-term estimation (reversed-time runs).



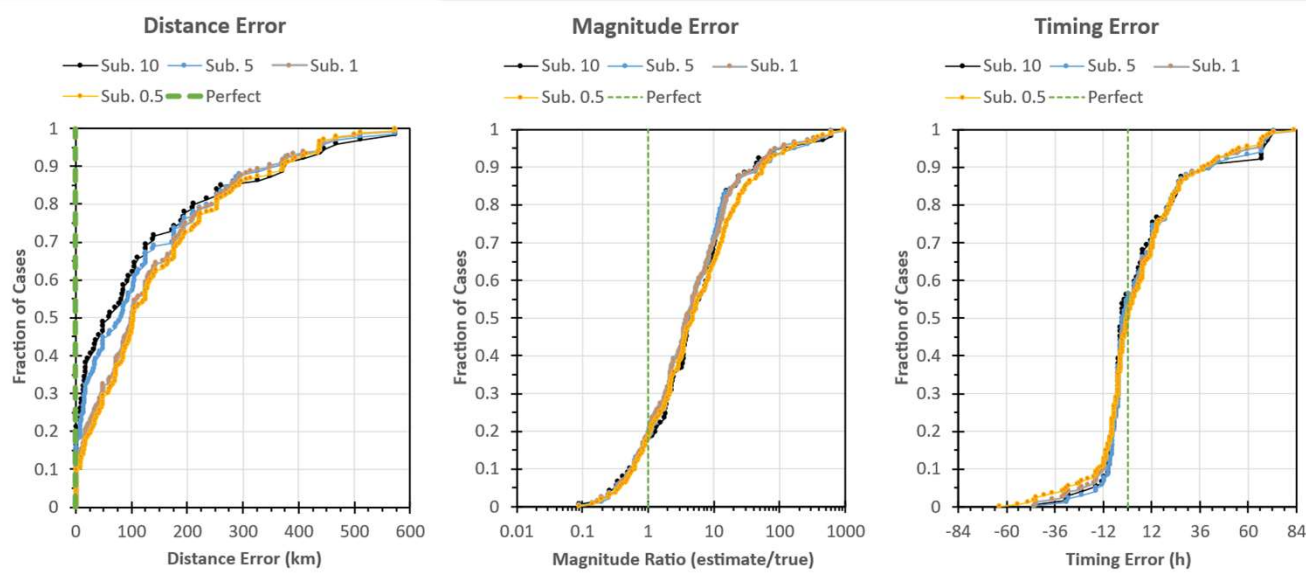
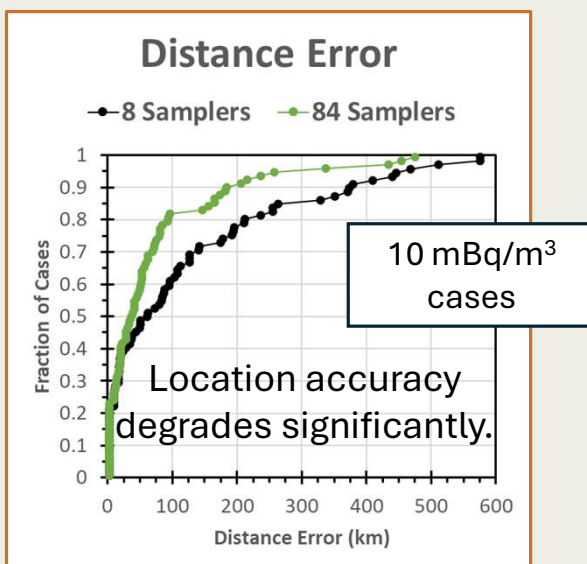
At least one sample with an increment of 1 to 5 mBq/m³ is needed to overcome most of the obfuscation from background sources.

Subset the release cases so the explosion causes increases at least one ^{133}Xe sample by:

- 0.5 mBq/m³ : 209 cases
- 1.0 mBq/m³ : 181 cases
- 5.0 mBq/m³ : 111 cases
- 10 mBq/m³ : 83 cases

Results Using Only 8 Samplers

Lose 40 more cases with no explosion contribution relative to 84 samplers. Magnitude estimates are biased high. Timing error is mostly unchanged.



At least one sample with an increment 5 mBq/m³ helps overcome the obfuscation from background sources.

In Summary

- As expected:
 - In some cases, it is possible to estimate release characteristics even in the presence of background emissions (especially for large releases)
 - Release events resulting in small sample concentrations may be hidden by the background emissions
- However:
 - In some situations, the release can be detected even when the sample increments caused by the release event are much smaller than the largest sample concentrations caused by the nuisance sources

Questions?

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