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Examining the potential for simultaneous detections of noble gas and particulate samples in the IMS RN network

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INTRODUCTION AND MAIN RESULTS

We examined six UNE release scenarios, including fractionated ones based on the literature, and subsequent atmospheric transport to IMS stations. The study identifies those radioisotopes (radioxenon and particulate) that are most likely to be detected on their own and as part of simultaneous noble gas and particulate detections, thus informing radionuclide data fusion efforts on the types of events that might be expected.

PNNL-SA-215744

SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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Introduction

In CTBT context, data fusion typically refers to RN/SHI fusion, but there is also interest in RN/NG fusion, which currently have two separate categorization schemes. We decided to investigate what RN/NG co-detections might look like in the IMS for a nuclear explosion, both to inform fusion studies but also to see what RNs on the long IMS relevant radionuclide list are most relevant.

Steps in setting up the study

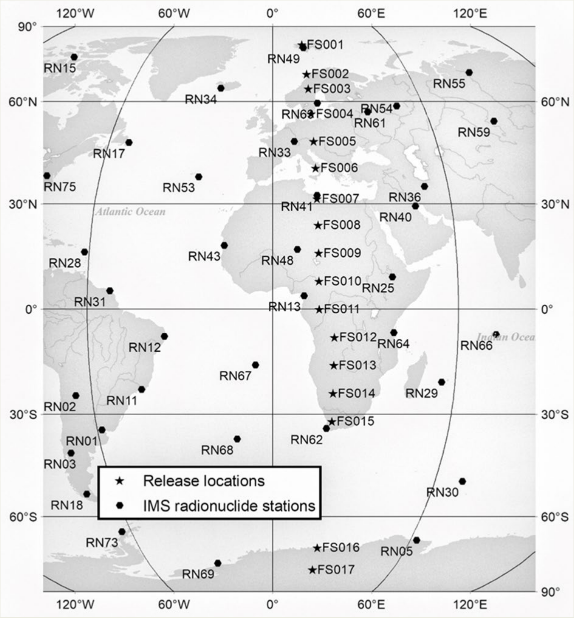
1) Define release scenarios (which isotopes and what magnitudes are released). Fractionation lives here!
2) Define a set of release locations and times
3) Perform an ATM run for each release to get concentrations at IMS station locations
4) Analyze the station results for multiple detections

Release Scenarios

- Release at 10 minutes, 1% each of particulate and RXe
- Release at 10 minutes, 1% RXe, 0.01% particulate
- Release at 24 hours, 1% each of particulate and RXe
- Release at 24 hours, 1% RXe, 0.01% particulate
- Release at 10 minutes using fractionation as described in Hicks Report (UCRL 52934)
- Release at 24 hours, using fractionation as described in Hicks Report.

Source Term Details

- 1 kT-equivalent fission of U-235 using Watt-fission spectrum neutrons
- Inventory change with time taken into account, before and after release
- 17 locations chosen. One release each day for 52 weeks and tracked with actual 2015 ATM data using HYSPLIT
- Determined average IMS RN MDCs for each relevant radionuclide by averaging ARRs from 2021
- No separation by atmospheric chemistry other than no wet or dry deposition for RXe



Results

See J. Env. Rad. 272 (2024) 107349 for full results.

12 radioisotopes were in the top 20 detected for all six release scenarios: I-132, Te-132, Ru-103, Mo-99, La-140, Ba-140, I-133, I-131, Te-131m, Xe-133, Sb-127, Rh-105. Just using these 12 radioisotopes would get the same overall particulate detection percentages as using the whole list for all of our scenarios.

Cd-115m never detected; Never detected above 10% in any scenario: I-130, Eu-155, Sm-156, Sb-125, Sb-126, Eu-157, Xe-131m, Sb-128, Te-129m

Fusion detection rate was driven by RXe in the prompt (10 minute) releases and the equal-amount one day release, due to particulate's better MDCs. The Fusion detection rate was driven by Particulate for the other two one day releases, where there was more RXe than particulate, reflecting Xe-133's high activity and long-ish half-life.

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Possible Future Work

- Apply this approach to more fractionation scenarios; explore fractionation phase space
- If one incorporated atmospheric chemistry, one could investigate a RN particulate pecking order (what isotopes are most likely to be seen when no others are seen)
- Extend this work to study plumes (multiple detections in time or number of stations)