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Radionuclide signatures from complex releases of vented fission products

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INTRODUCTION

This project builds on previous work modeling the detection of noble gases at IMS stations, now incorporating a variable vent fraction for both prompt and delayed releases of fission products from a simulated underground nuclear explosion

METHODS/DATA

A set of radionuclide inventories were developed using SCALE, and modified using dilution factors from the atmospheric transport modeling tool HYSPLIT

START

RESULTS

Example:
10% prompt vent
+ 10% delayed vent
↓
Four hypothetical detections of Xe-133 at JPP38 within 10 days

CONCLUSION

Study will be expanded with one year's worth of start dates for ATM models through Texas Advanced Computing Center

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Introduction

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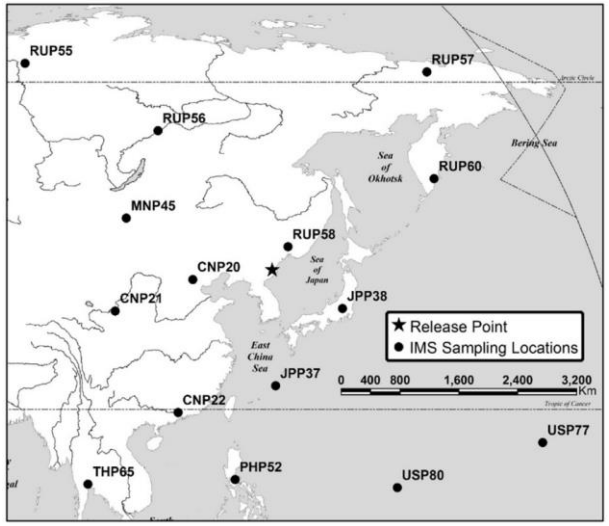
Context: Nuclear Explosion Monitoring



IMS stations in proximity to a hypothetical release point[1].

This project builds on previous work modeling the detection of noble gases at IMS stations, now incorporating a variable vent fraction for both prompt and delayed releases of fission products from a simulated underground nuclear explosion.

Problem: Uncertain particulate and noble gas venting fractions

Table 1: Isotope activity for prompt and delayed vent

Isotope	Prompt Activity (Bq)*	Delayed Activity (Bq)
Xe-140	1.24E+21	0
Xe-137	8.37E+19	0
Xe-135m	1.02E+18	2.05E+16
I-135	7.92E+17	1.19E+17
Xe-135	1.66E+16	3.24E+17
I-133	1.11E+16	2.33E+17
Ba-140	1.90E+15	2.95E+16
La-140	1.02E+14	1.03E+16
Xe-133m	9.12E+13	2.65E+15
I-131	2.32E+13	2.10E+16
Xe-133	1.32E+13	4.08E+16
Cs-137	8.97E+11	3.68E+13
Xe-131m	1.63E+09	1.25E+13

Table 2: Prompt/delayed release fractions

	Prompt	Delayed
Noble Gases	10% 1% 0.1% 0%	10% 1% 0.1% 0%
Particulates	0.1% 0.01% 0.001% 0%	

*Note for Table 1: Prompt release Xe-140 is decayed to Ba-140 and Xe-137 to Cs-137

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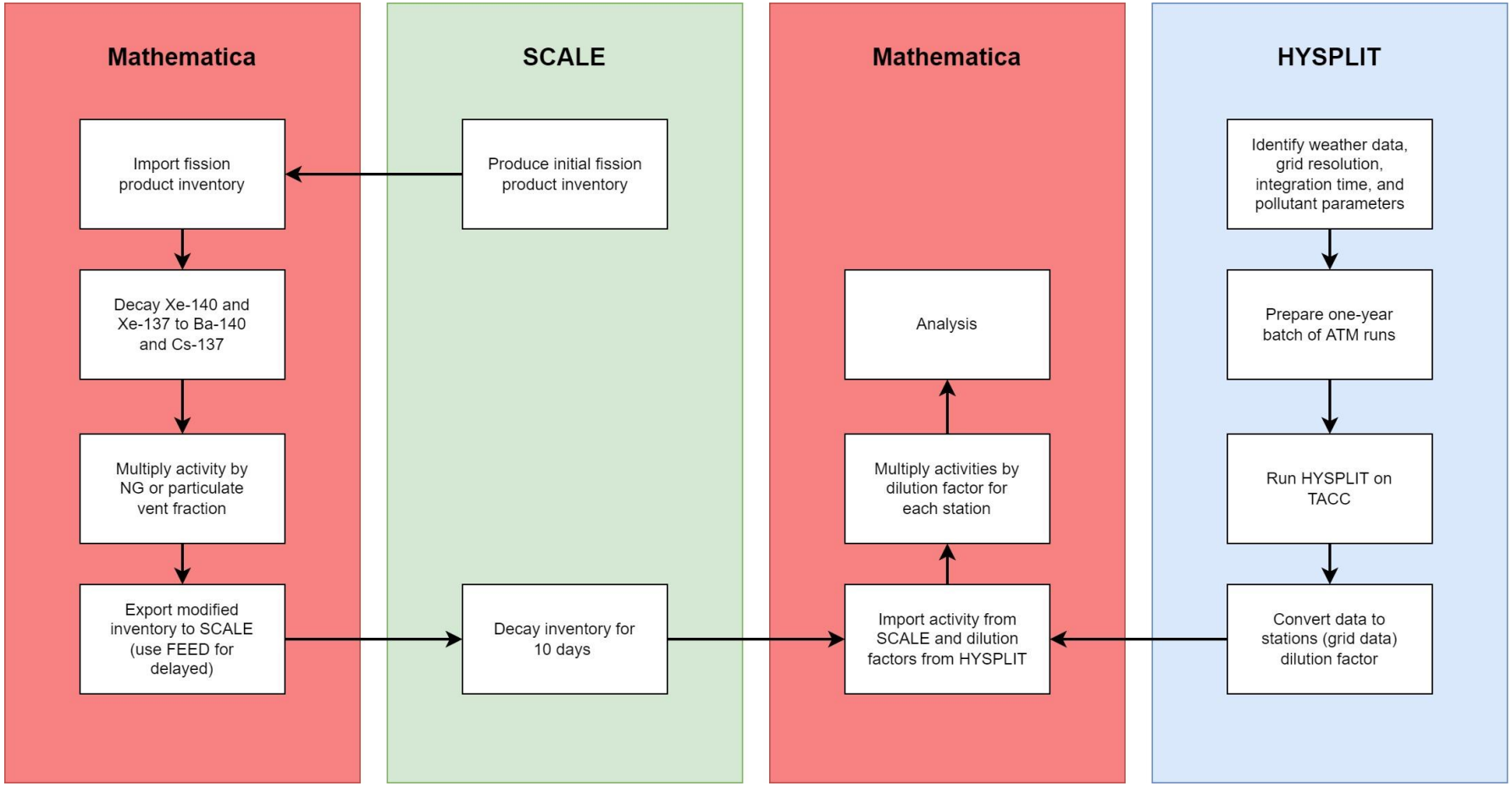
Methods – Modeling and Simulation Tools



Flowchart for the combination of atmospheric transport modeling tool HYSPLIT and nuclide inventory tracker SCALE with data processing tool Mathematica

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Methods – Simulation Parameters

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Table 3: HYSPLIT and SCALE simulation parameters

Dilution Factor		**Nuclide Activities**	
Release Time	Daily releases from Jan 1 to Dec 31, 2020	**Transport Time**	1 hr increments to 10 days
Transport Time	1 hr increments to 10 days	**Prompt Vent**	Tables 1-2
Position	Origin: (41.28, 129.09) Corner: (11.25, 84)	**Delayed Vent**	Tables 1-2
Deposition	Noble gas, iodine or particulate	**Fission Nuclide**	U-235 or Pu-239

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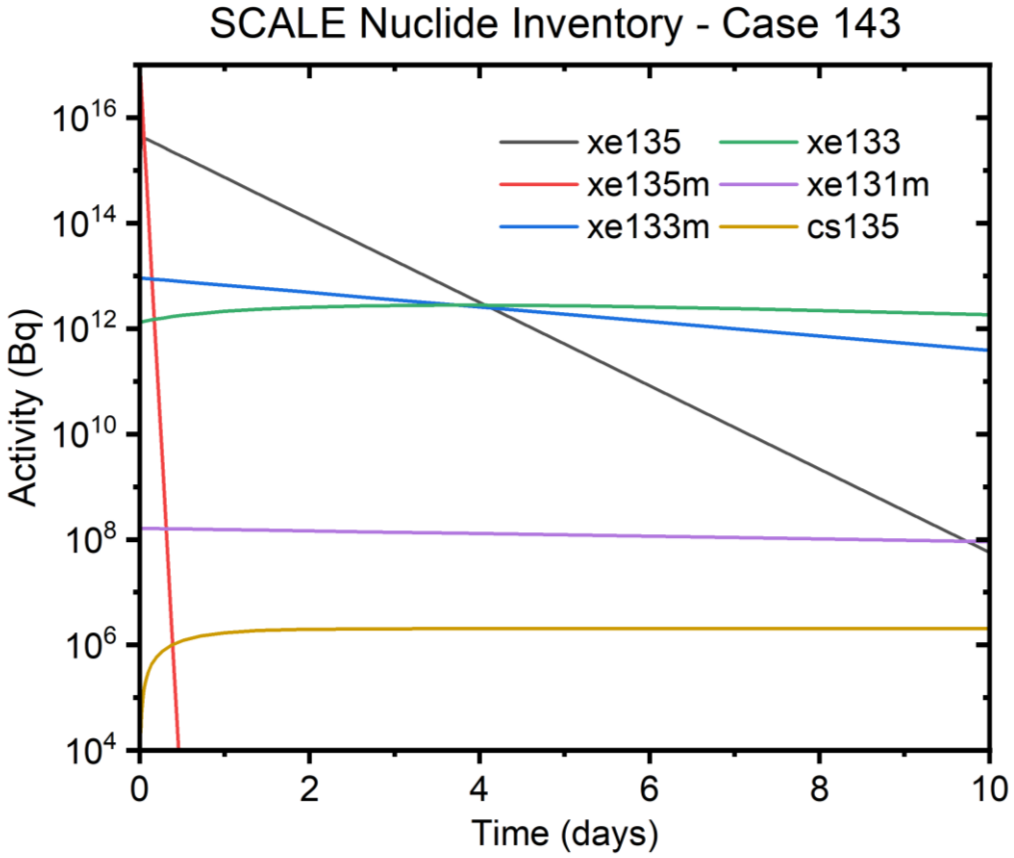
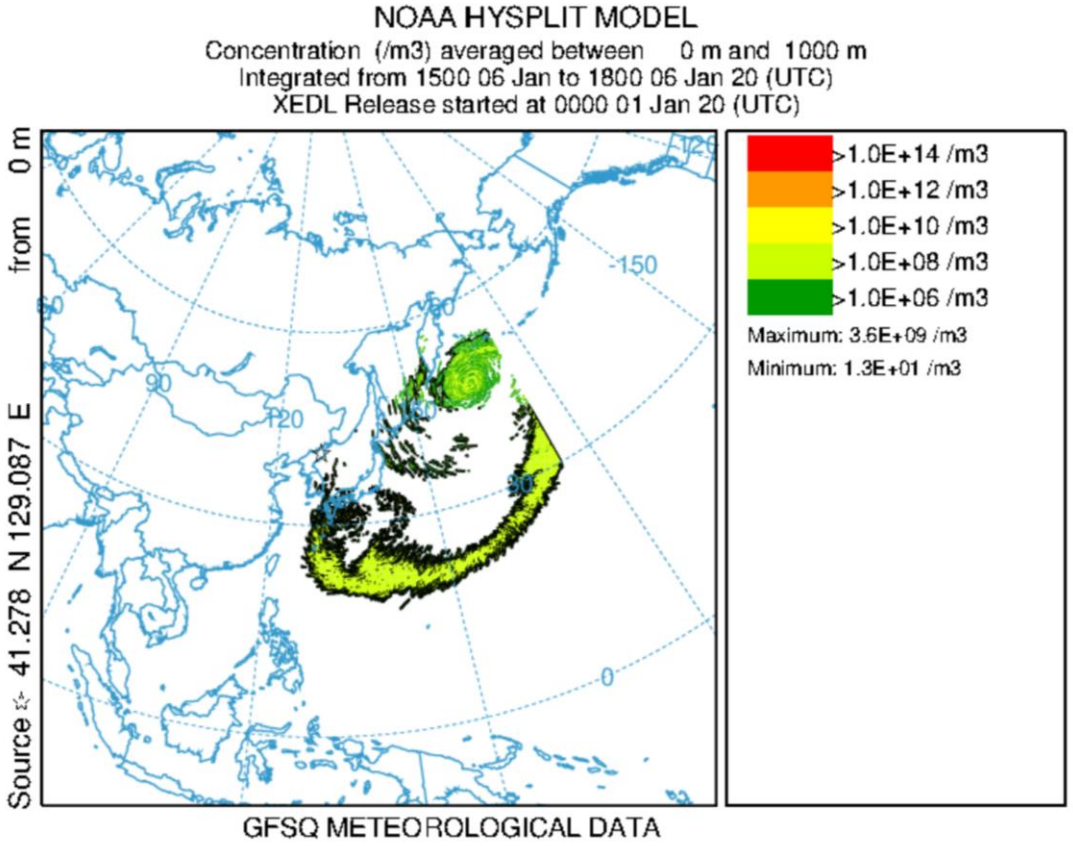
Results – Simulation Output



Activity from SCALE



Dilution factor from HYSPLIT

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Example Results and Conclusion

Results – Example

- Case 111: 10% prompt vent + 10% delayed vent
- Release date: January 1, 2020
- Non-zero dilution factor at JPP38 in 10 days following release
- Xe-133 MDC = 0.15 mBq/m3
- Four detections of Xe-133 at JPP38 in the 10 days following January 1, 2020

Next Steps

- Use Texas Advanced Computing Center's Lonestar6 to run HYSPLIT for one year's worth of start dates
- Combine dilution factors from HYSPLIT with nuclide inventories from SCALE
- Tally number of detections per station per isotope
- Look for changes in signatures including xenon ratios based on vent fractions

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References

1. Haas, D. A., Eslinger, P. W., Bowyer, T. W., Cameron, I. M., Hayes, J. C., Lowrey, J. D., & Miley, H. S. (2017). Improved performance comparisons of radioxenon systems for low level releases in nuclear explosion monitoring. *Journal of Environmental Radioactivity*, 178, 127-135.

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