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Modeling the use of mobile modular gas samplers in near-field detection using HYSPLIT

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INTRODUCTION

GOAL: Determine sampler network effectiveness in detecting Xe-133 as a function of sampler density and distance from emission point using atmospheric transport modeling.

METHODS/DATA

ATM using inline WRF-HYSPLIT

Parameters Varied
- Number of Samplers
- Release Date
- Release Duration
- Sample Collection Interval

START

RESULTS

- Primary plume detected in 56/80 scenarios
- Secondary plume not detected
- Sampler density important for network effectiveness

CONCLUSION

Sufficiently dense network could detect 10^{13} Bq ^{133}Xe release up to 15 km away

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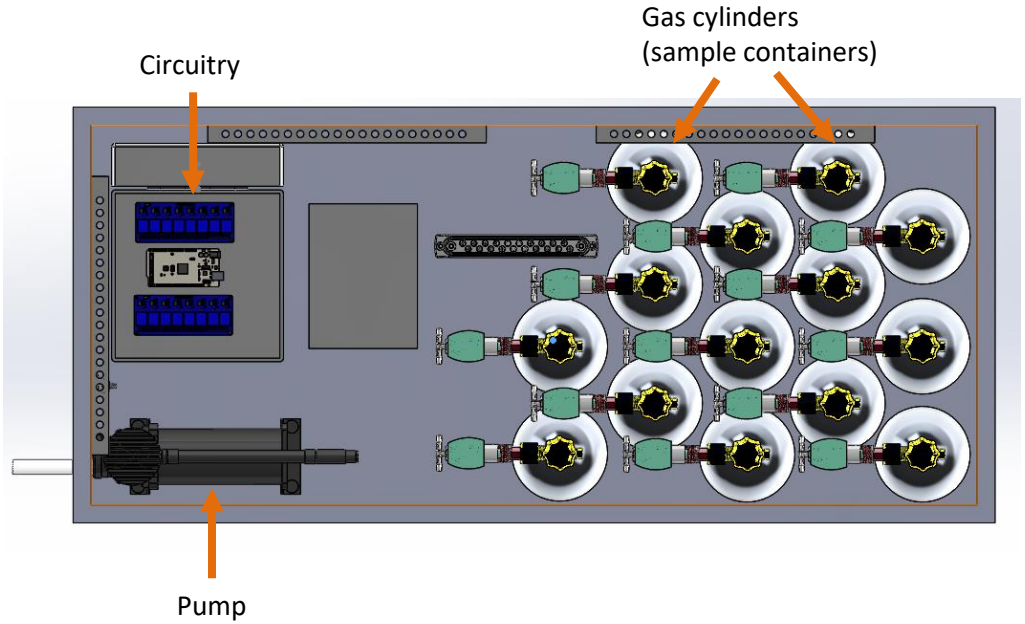
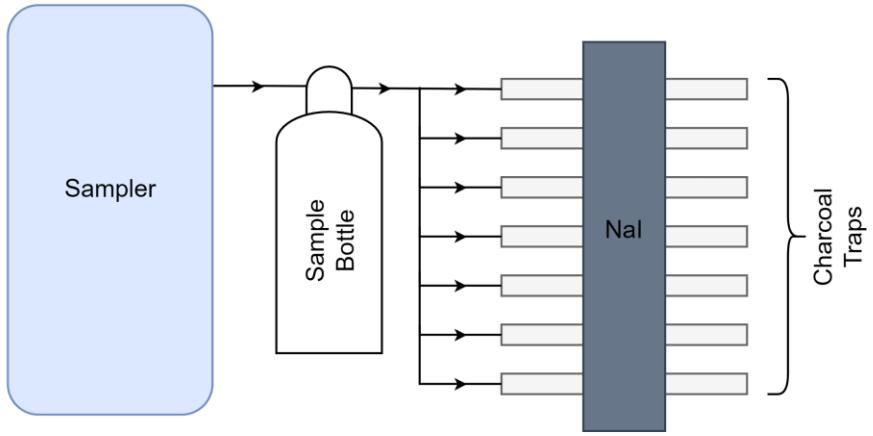
Introduction: WINGS Design

Wireless Independent Noble Gas Sampler (WINGS)



WINGS system design by UT researchers



Sample analysis using charcoal traps and NaI detector

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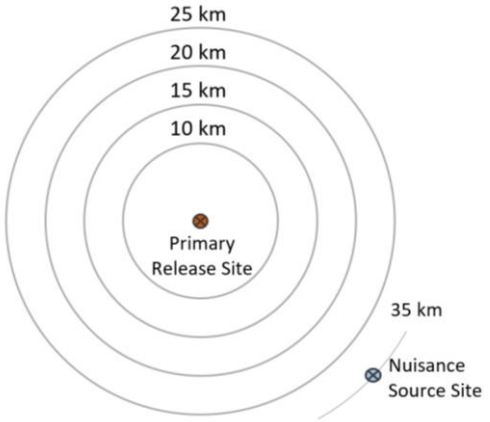
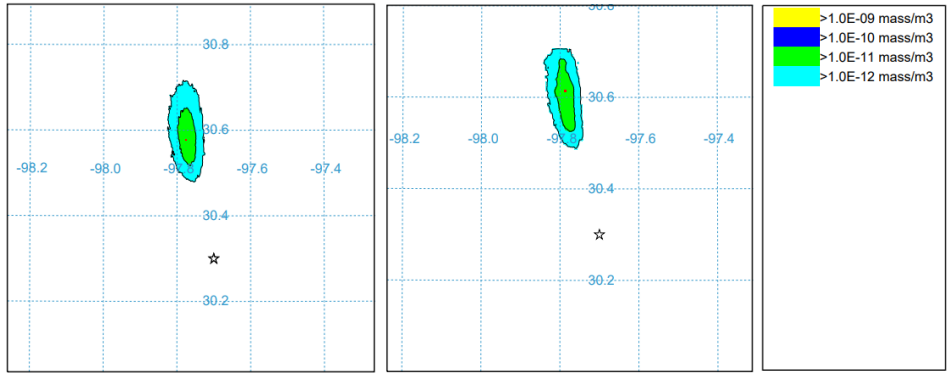
Methods: Inline WRF-HYSPLIT

Samplers Placement



Release points and radial locations of samplers (WINGS) in HYSPLIT simulations

Inline WRF-HYSPLIT



Comparison of standard HYSPLIT model using GDAS 1° meteorological data (left) and inline WRF/HYSPLIT (right)

Simulation parameters

Parameter	Value
No. Samplers	10, 50, 100, 250, 500
Release Date	Mar 1, Jun 1, Sept 1, Dec 1 (2020)
Release Duration	5 min
Sample Collection Interval	5 min
Simulation Duration	60 min
Sampler MDC	10 Bq/m^3 (Xe-133)
Primary Emission	10^{13} Bq Xe-133
Nuisance Emission	10^{10} Bq Xe-133

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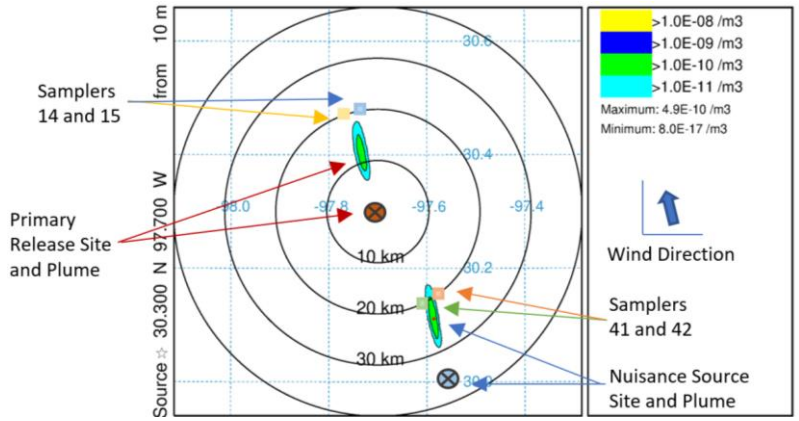
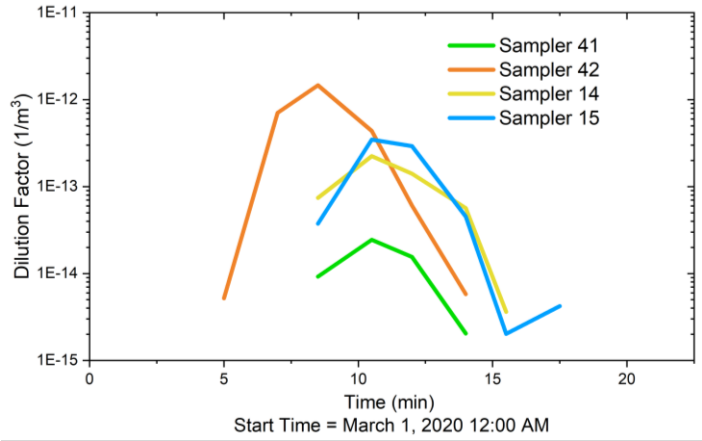
Results

Example Output



Example output: sampler locations, plumes from primary and nuisance release sites for March 1, 2020 release date



Dilution factors at stations intercepting the plumes for March 1, 2020 release date

Results

Distance	# Samplers	Detection							
		Mar		Jun		Sept		Dec	
		P	N	P	N	P	N	P	N
10 km	500								
	250								
	100								
	50								
	10								
15 km	500								
	250								
	100								
	50								
	10								
20 km	500								
	250								
	100								
	50								
	10								
25 km	500								
	250								
	100								
	50								
	10								

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Discussion and Conclusion

Conclusions

- Detecting plumes entering or leaving an area of interest is feasible using WINGS.
- With thinner networks (fewer samplers), plumes will escape without detection
- Sampler networks placed closer to primary site had a higher chance of detecting the primary plume but higher dilution factors for plumes traveling from the nuisance release point

Continuation of Work

- Reduce granularity in parameter values
- Increase number of simulations for quantitative analysis
- Extend analysis to include other Xe isotopes

Acknowledgments

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References
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Shah, K. A., Gordon, E. M., Adhikari, P., Allen, M. I., Anderson, N. D., Bekker, J., ... & Haas, D. A. (2022). Portable modular gas samplers for nuclear explosion monitoring. *Journal of Radioanalytical and Nuclear Chemistry*, 1-6.

Gordon, E. M., Adhikari, P., & Haas, D. A. (2022). Modeling the use of mobile modular gas samplers in near-field detection. *Journal of Radioanalytical and Nuclear Chemistry*, 1-6.

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