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Characterizing the Background Variability of Radionuclides at International Monitoring System Stations

Donald D. Lucas, Lee Glascoe, and M. Giselle Fernández-Godino

P2.4-125

POSTER

Lawrence Livermore National Laboratory

NNSA National Nuclear Security Administration

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ABSTRACT

A variety of factors influence the atmospheric background of ubiquitous radionuclide signatures, like xenon-133, measured at International Monitoring System (IMS) stations. Variability in the radionuclide background obscures the categorization and discrimination of signals from nuclear weapons testing and civilian and industrial activities tied to medical radioisotope production and nuclear power reactors. The radionuclide background fluctuates due to synoptic weather events, temporal changes in background sources, and site-specific details related to the placement of IMS stations. To better characterize the radionuclide background, we have statistically analyzed a set of factors that may be associated with background variability. These factors include historical IMS measurements, weather reanalysis products, high-resolution spatial topographic and land-use data, and a large collection of atmospheric transport modeling simulations. We use this dataset to assess the relationships between potential background sources, site-specific characteristics, and signals at IMS stations, including an assessment of stations susceptible to large variations in background. This assessment may improve our understanding of the radionuclide background and may aid event characterization and analysis of data at the International Data Centre. (LLNL-ABS-816283)

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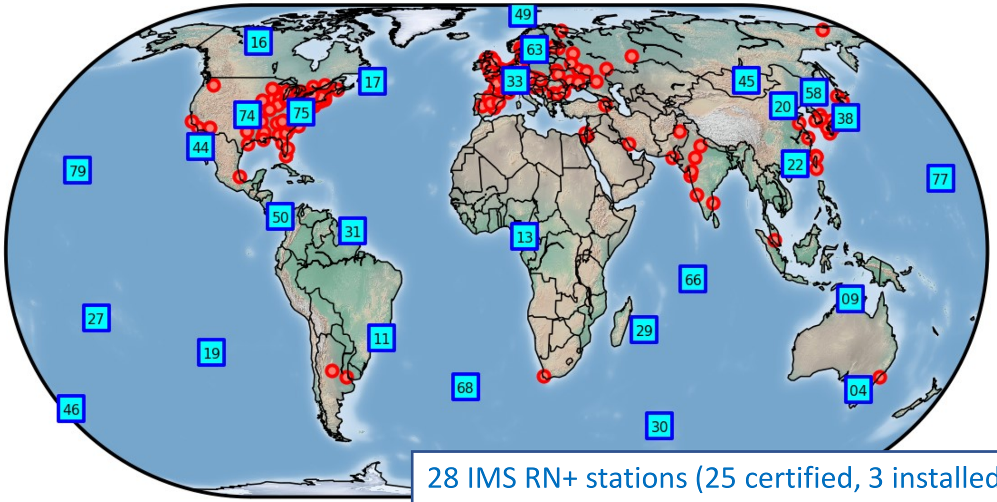
INTRODUCTION

The variability of background radionuclide levels can differ from one IMS station to another. Many factors can cause differences in background variations:

- Different meteorological conditions
- Proximity to background sources from nuclear reactors and medical isotope facilities.
- Local land surface characteristics
- Complex terrain and elevation

We use a combination of data and models to analyze the role these factors play in radionuclide variability



28 IMS RN+ stations (25 certified, 3 installed)
205 nuclear power plants, research reactors, and medical isotope facilities

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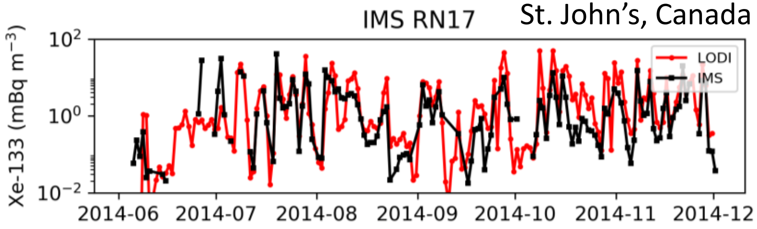
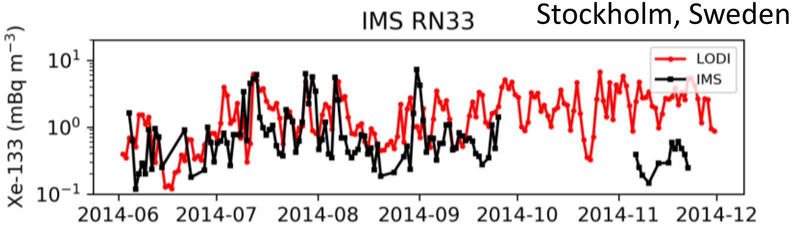
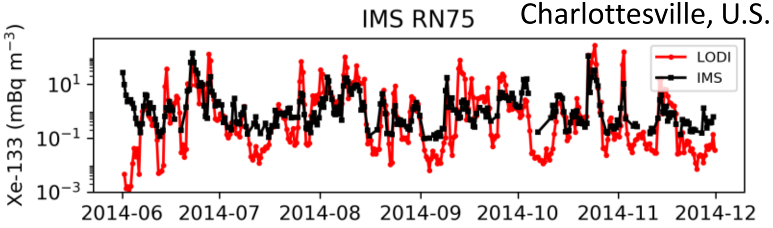
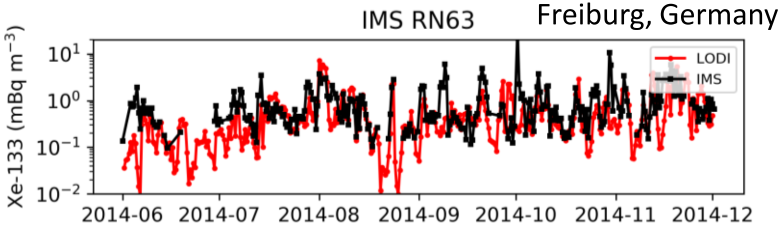
RESULTS

Background xenon values at IMS stations can vary over many orders of magnitude









Simulations of background xenon-133 using the LODI model compare well to measurements at IMS stations for Jun-Dec 2014. We can use the model to estimate high frequency variability.

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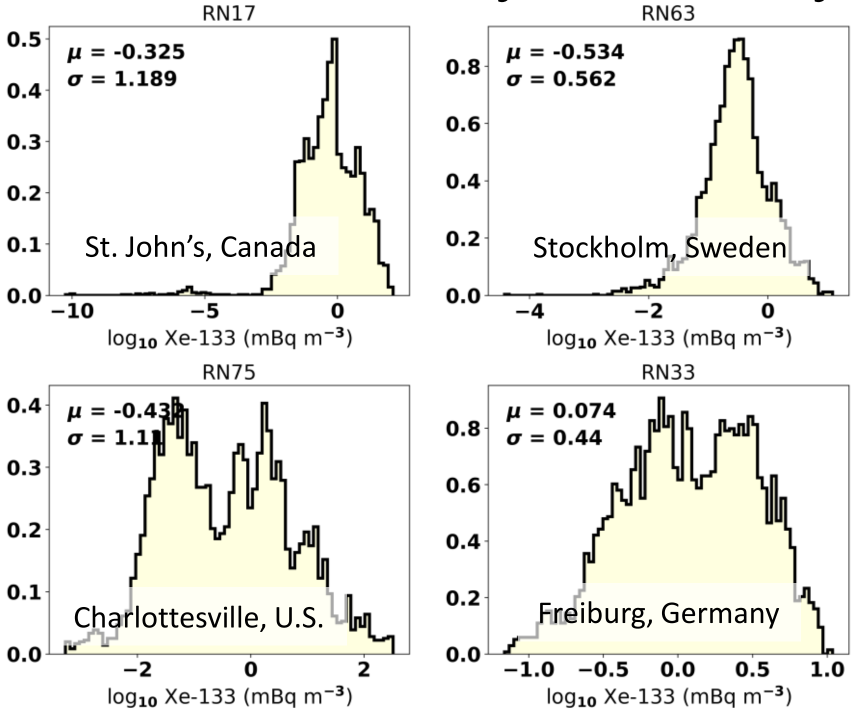
Variability in background Xe-133 is shown using histograms of high-frequency signals simulated using the LODI model at four IMS stations over Jun-Dec 2014.

High variability is present at St. John's and Charlottesville, and moderate variability at Stockholm and Freiburg.



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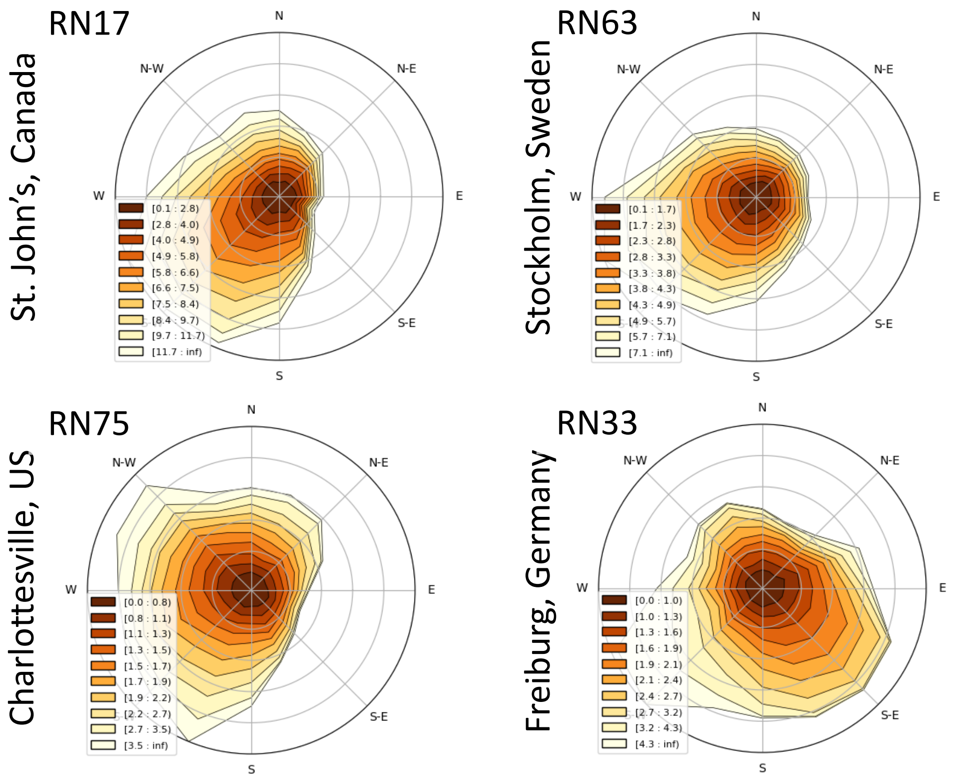
RESULTS

Meteorological patterns may impact variability in radionuclide measurements.

The wind roses show the climatological wind speed and direction at IMS stations over 2015-2019 using the 0.5-degree Global Forecasting System weather data.

Winds at the Charlottesville and Freiburg IMS stations tend to be more variable than winds at St. John's and Stockholm.



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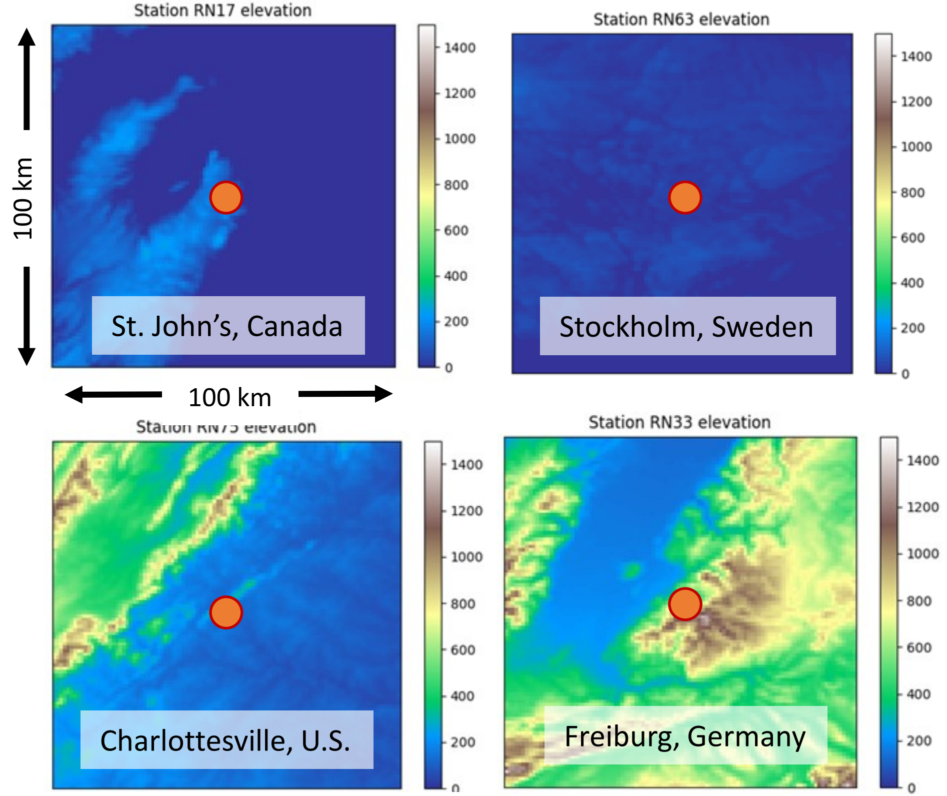
RESULTS

Local-to-regional topographic features around IMS stations may impact variability in radionuclide measurements.

For each station we analyzed elevation in 100 km by 100 km areas around the stations using the ETOPO1 global digital elevation model with a 1 arc-minute resolution.

The IMS stations at Charlottesville and Freiburg are in regions with more topographic variability than Stockholm and St. John's.



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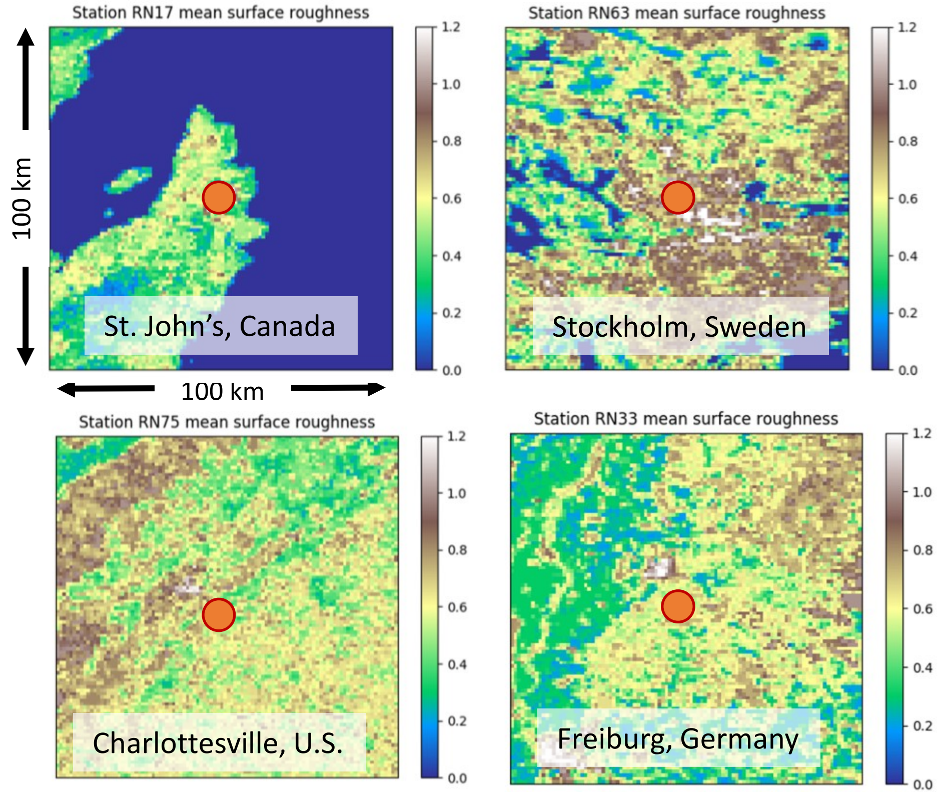
RESULTS

Vegetation, urban areas and water bodies around IMS stations affect atmospheric turbulence and may impact variability in radionuclide measurements.

We calculated surface roughness in 100 km by 100 km areas around IMS stations using a 1-km global land use database with 12 land categories. Values of 0 and 1 represent smooth and rough surfaces, respectively.

The IMS stations at Charlottesville and Freiburg are in regions with moderate surface roughness. Stockholm has high surface roughness (i.e., urban) and St. John's has low surface roughness.



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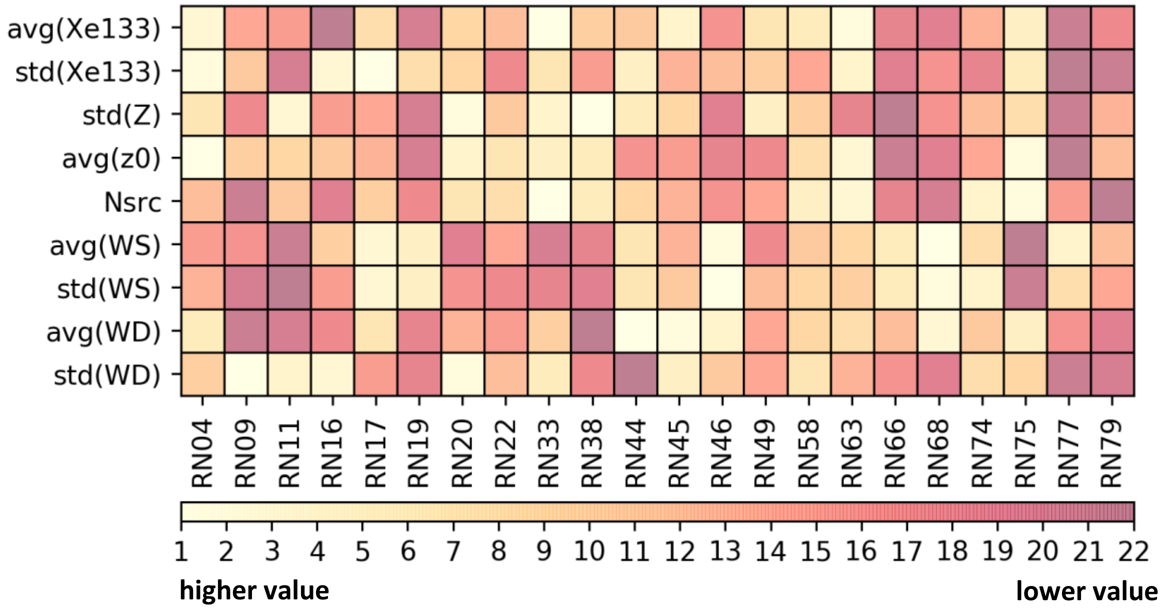
CONCLUSIONS

Summary of the relationship between elevated radioxenon statistics and spatial, environmental, and meteorological variability at selected IMS RN stations



- The chart shows the relative order of values across the RN stations for each quantity.
- Stations with high variability in xenon also tend to have high values of surface roughness (z0).
- Stations near many potential sources (Nsrc) also exhibit high xenon variability.

Z = elevation, z0 = surface roughness, WS = wind speed, WD = wind direction, and Nsrc is the number of sources within 1500 km.

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CONCLUSIONS

- We have quantified the levels and variability of background radioxenon at IMS stations from measurements and model simulations.
- Using global datasets, we have also computed many other factors that may influence background radioxenon variability (meteorological conditions, proximity to sources, local land characteristics, and elevation changes).
- IMS stations with relatively high levels of background xenon variability also tend to be in areas with high surface roughness, which can enhance turbulence.
- The number of nearby nuclear reactors and isotope production facilities also appears to be associated with high background xenon variability.

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