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Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

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INTRODUCTION

Radionuclide background interference in nuclear explosion detection is known, but vertical distribution impacts are less studied. We propose experiments to test decreasing background effects at IMS stations and explore tradeoffs to better constrain background emissions.

METHODS/DATA

We have performed atmospheric transport calculations that show vertical gradients of radionuclide concentrations appear to occur at local, regional and global scales.

START

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P2.4-337

RESULTS

Based on our calculations, we suggest an experiment to be conducted on a tower in a source rich part of the globe at least 100 m altitude. Weather towers of 100 m are common, and some exceeding 300 m also exist.

CONCLUSION

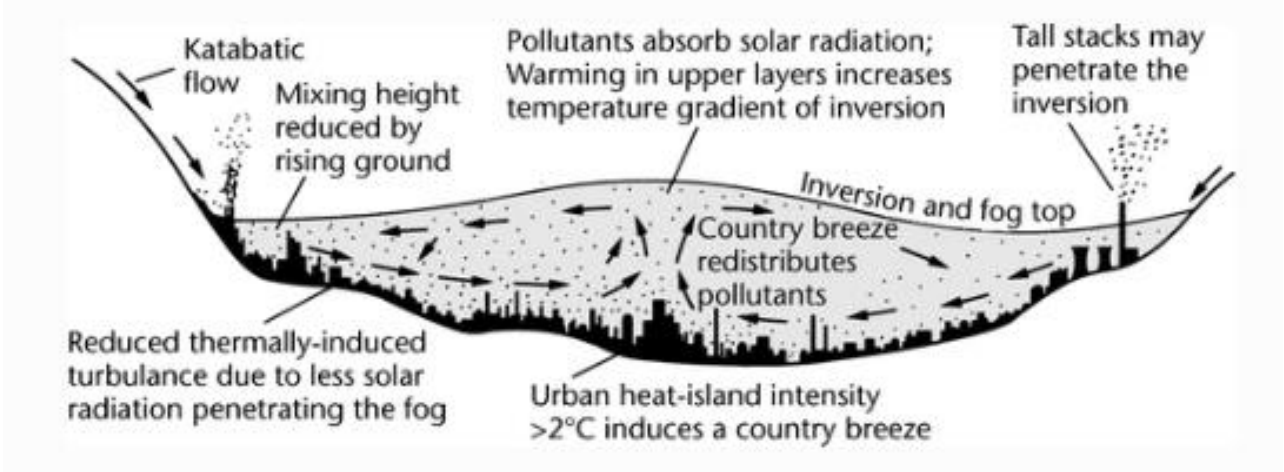
Calculations show that incomplete vertical mixing vs distance may allow for some distance discrimination of a source of radionuclides. We propose an experiment to study vertical measurements performed altitude to test these calculations.

XenonQuest

Introduction: Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

- The International Monitoring System (IMS) detects CTBT relevant radionuclides nearly every day at many of its noble gas and particulate stations.
- IMS measurements are performed at ground level, however, we suggest that under some circumstances, measurements at altitude could be useful to discriminate local vs. distant sources and thereby improve categorization of radionuclide detections
- Local emissions often overwhelm nearby IMS stations complicating the CTBT's monitoring goals
- The presented analysis highlights the utility of considering vertical gradients; we believe this warrants further study
- Based on our calculations, we propose that an experiment could be conducted to test this hypothesis

Image: Igors Jefimovs



From: DG Steyn, et al. 2013, doi 10.1007.978-94-007-4098-3_5

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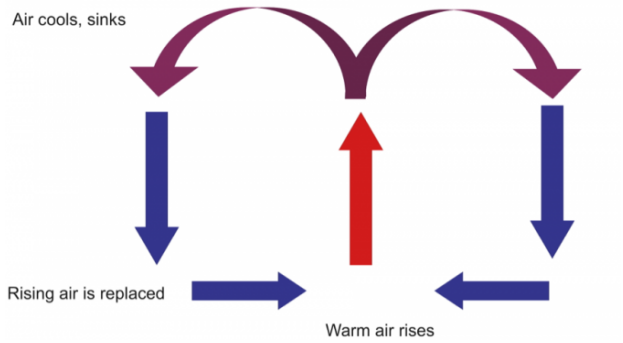
Objectives: Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

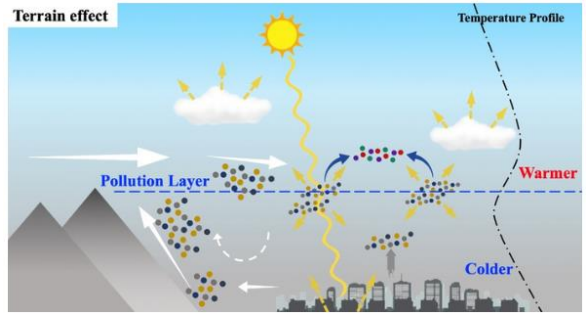
Factors that affect vertical mixing

- Land regional topography
- Energy (temperature) of injection
- Height of release
- Vertical shear
- Ground resuspension
- Building wake effects
- Convective mixing
- Night/day lofting

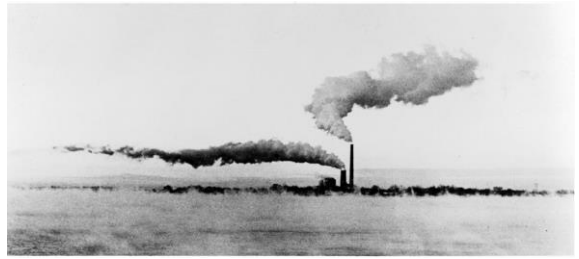
Global/thermal lofting mixing



Terrain mixing



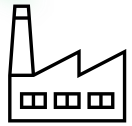
Boundary Layer Dynamics



Concept

- Under the same atmospheric conditions, sources closer to the monitoring station typically experience less overall mixing (yellow versus green plumes)
- Depending on atmospheric conditions and distance, ground level emissions may not mix vertically (yellow plume)

Hypothetical fracture from UNE



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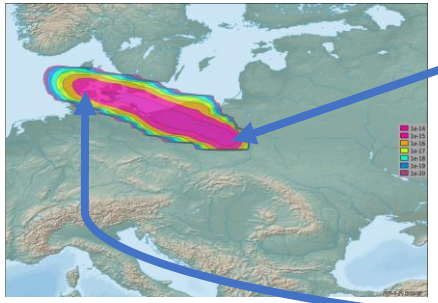
Methods/Data: Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

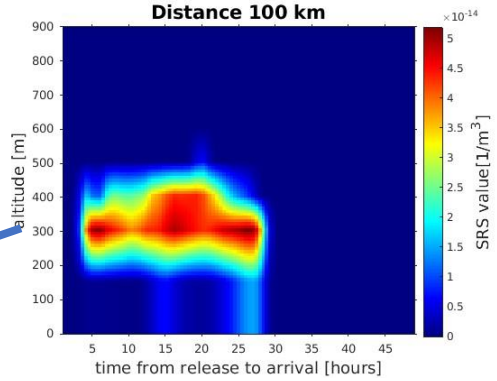
METHODS

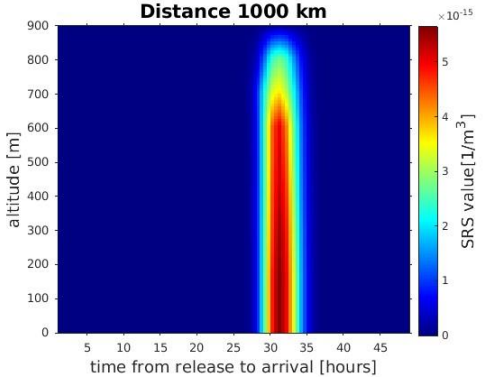
Regional

- Regional scale calculations (0.5° x 0.5°) Flexpart release across Europe
- 24-hr duration release followed for 48 hrs

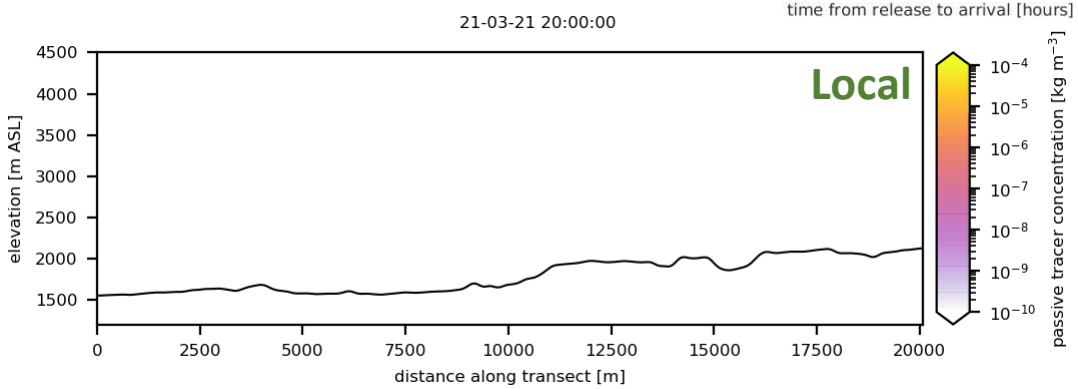


Release point (lat 52.23, long 21.01) for a hypothetical unit release on 24 Nov 2019





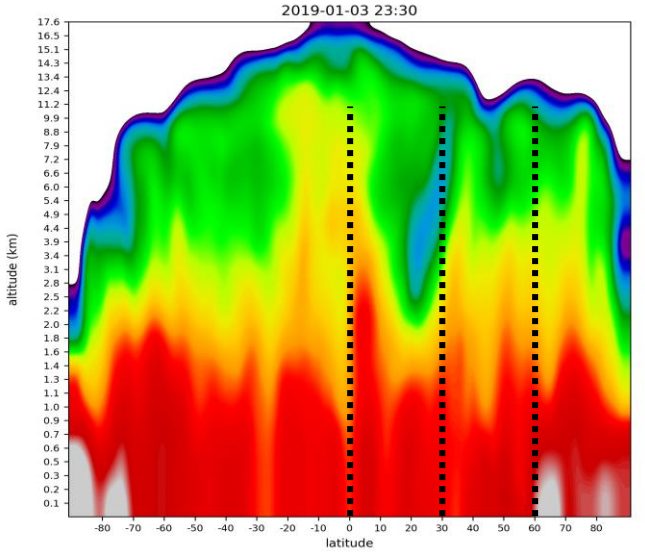
- Local scale calculations (40m resolution) using WRF-LES across Nevada
- Note evolution of vertical mixing with distance



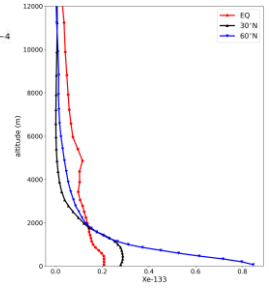
Vertical Structure of radionuclide mixing is observable at all scales

- Vertical structure can vary with distance from a source depending on terrain and atmospheric conditions both locally and regionally
- Vertical structure of background varies locally, regionally, and globally

Global



- Global scale calculations (2° resolution) using global ATM model of radioxenon background
- Note longitudinal average of zonal mixing plotting latitude vs altitude



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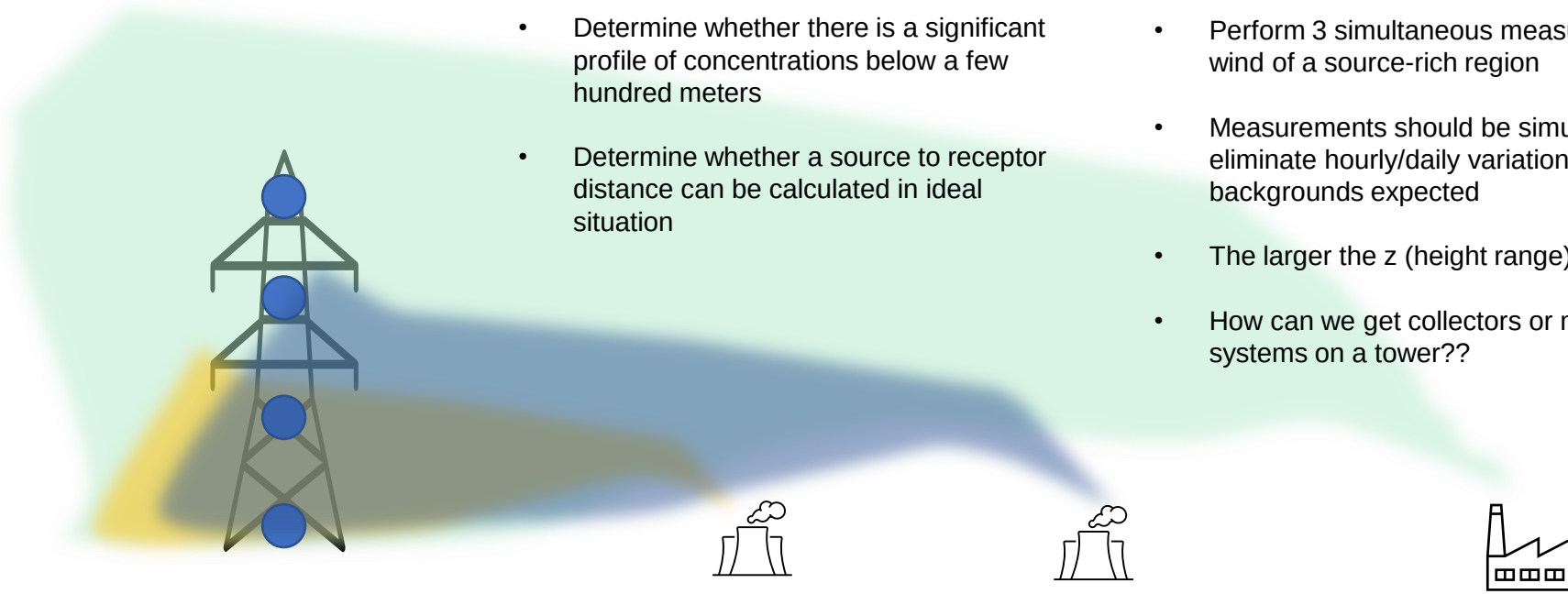
Results: Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

Vertical Mixing Experiment



Experimental Goals

- Determine whether there is a significant profile of concentrations below a few hundred meters
- Determine whether a source to receptor distance can be calculated in ideal situation

Experimental Design

- Perform 3 simultaneous measurements down wind of a source-rich region
- Measurements should be simultaneous to eliminate hourly/daily variations in backgrounds expected
- The larger the z (height range), the better
- How can we get collectors or measurement systems on a tower??

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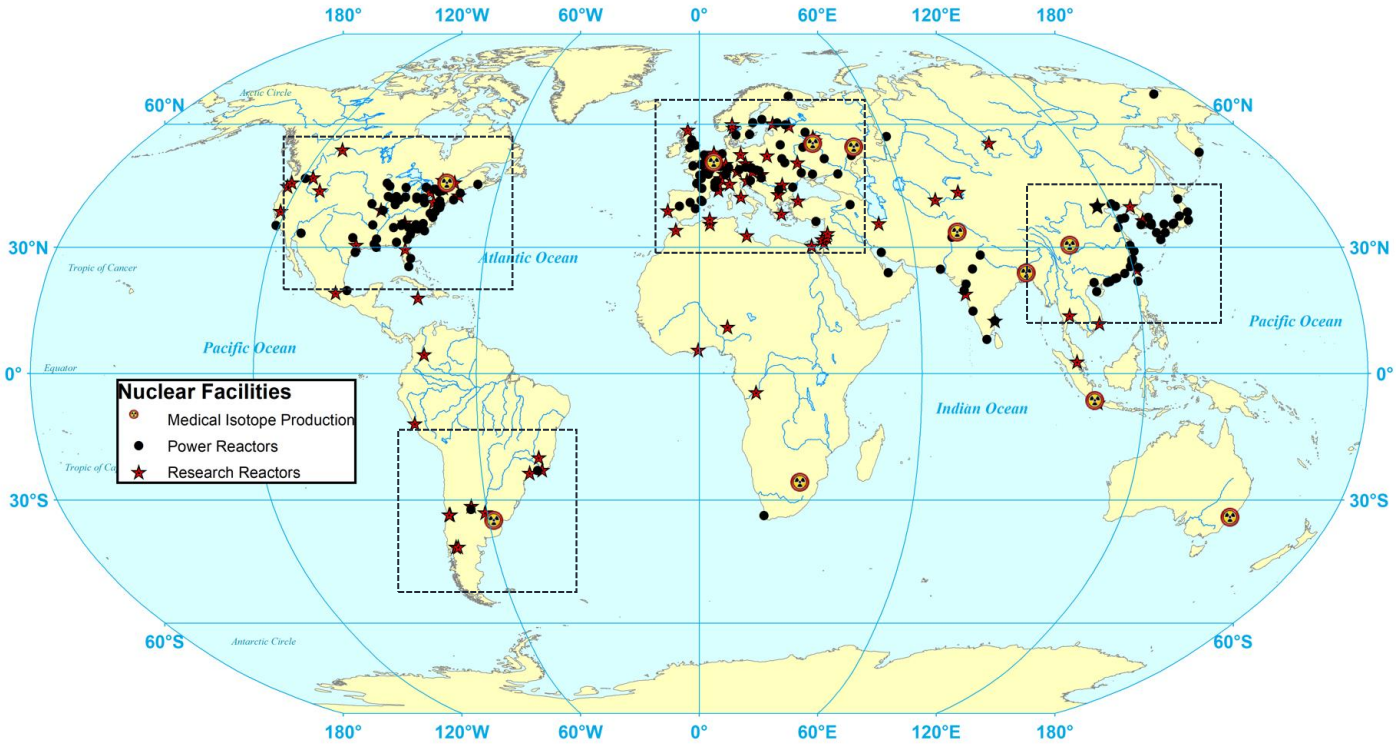
Results: Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

Experiment Location

Optimal location for experiment

1) Source rich location
2) Access to high towers
3) Access to stack data



Towers

- There are a few towers in the 300m+ height range, but they are not in ideal locations for this study
- There are many ~100m towers spread across the world and they can be purchased cheaply

Amazon Tall Tower (325 m height)

KNMI-mast Cabauw (213 m height)

(Netherlands)

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Conclusion: Factors Affecting the Vertical Distribution of Backgrounds at IMS Stations

Conclusions

- It appears that in a number of cases, mixing is not sufficient to homogenize radionuclides at local or to regional distances, but mixing appears to be more complete at larger distances
- We propose an experimental campaign to study the value of a series of vertical measurements performed on a tower (or balloon) to study whether the calculated effect is reproducible and whether the profile of concentrations could be used to help radionuclide screening
- The experiment will require a high tower, ideally with a height of at least 100m, and the ability to instrument collectors or small samplers at altitude
- While each situation may be different due to local conditions, as atmospheric transport modeling progresses, this additional constraint on models could prove to be useful in the future

References
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