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Event Analysis of CTBT Relevant Radionuclides Detected in the Nordic Region 2020

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ABSTRACT

A series of measurements of multiple anomalous treaty relevant radionuclides at several measurement stations in Sweden and Finland, including the Stockholm aerosol sampler (SEP63) in the International Monitoring System (IMS), occurred in the summer of 2020. The cause and source of these radionuclides is still unknown. The laboratory re-measurement of the split IMS sample revealed that one-half of the split sample contained the entirety of the anthropogenic radioactivity - a high degree of sample inhomogeneity due to hot aerosol particles. Using the IMS results and by performing some advanced laboratory coincident measurement techniques, an international, multidisciplinary team started to unravel the details on the nature of this event while also demonstrating the verification benefits of adopting new sample analysis techniques.

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INTRODUCTION

- Beginning in early June 2020, ^{103}Ru, ^{134}Cs, ^{137}Cs, ^{60}Co was reported in Northern Europe on national and CTBT samplers
  - Sweden, Finland, Estonia reported observations
  - ~45 States reported that they observed nothing and were unaware of any emissions from their territory
    - Some reports were in immediate region (e.g. Latvia, Lithuania, Albania, Russia) and some distant (Qatar, USA, Morocco, Algeria)

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METHODS

- Only two reported observations were 24 h samples. The remainder (4) were weekly samples which made it difficult to characterize event location
- Collection of debris suggests "chunky" material rather than homogeneous dispersed aerosols
  - the Stockholm IMS sampler SEP63 is co-located with a Swedish national sampler. Only the IMS sampler observed radionuclides
- No particulate isotope has a noble gas precursor or product that can be observed by CTBT noble gas samplers
- All particulate activity concentrations were quite small – no health risks

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METHODS

- Approach involved:
  - Re-measure filter pieces from Helsinki and Visby using advanced dual-gamma coincidence spectroscopy
  - Model the isotopic results using reactor burnup code for two reactor designs (RBMK, VVER) in region
  - Model atmospheric transport and dispersion (ATM) using forward and backward simulations from potential sites.

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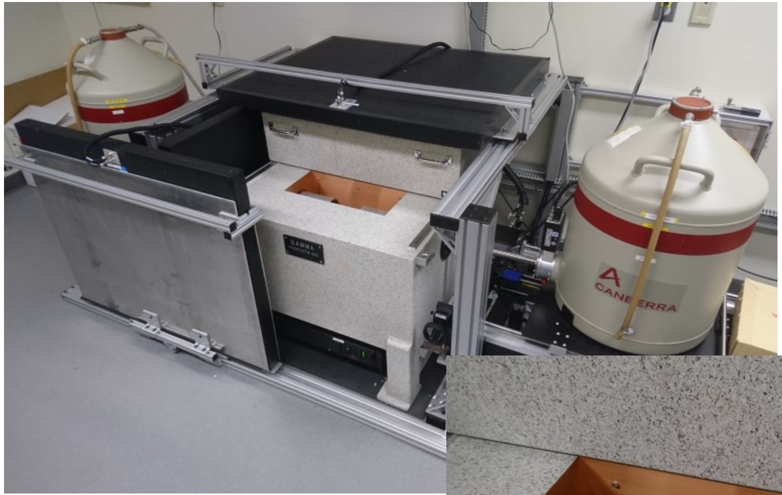
METHODS

Several samples were sent to Health Canada for remeasurement on the **ThinMan detector system**, consisting of:

- Two CANBERRA BEGe5030s
- Custom graded shield
- Plastic scintillator cosmic veto panels
- CANBERRA LYNX MCAs



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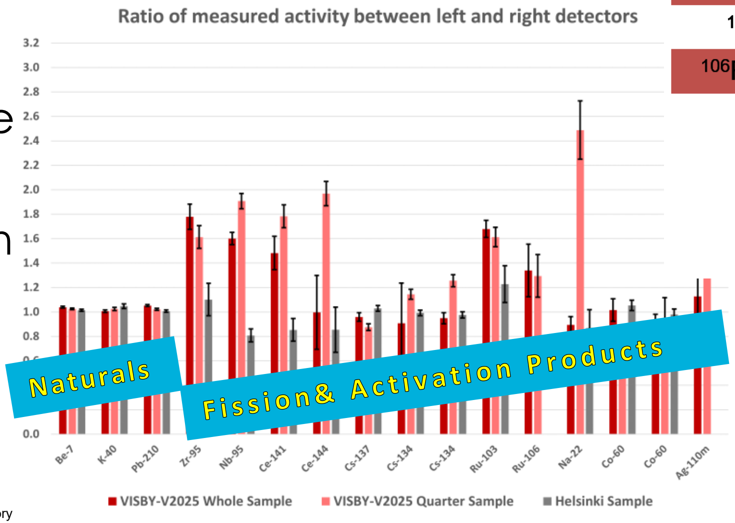
RESULTS

Remeasurement of samples:

- Increased the **number** of detected isotopes
- Resulted in more **precise quantification** of their activities and ratios

- Further investigation was performed to determine the nature of the deposition within the air filter sample
- Inhomogeneity present with fission products while naturals homogeneous



Identified isotopes:

Original	ThinMan
^{95}Nb	^{95}Nb
^{95}Zr	^{95}Zr
^{134}Cs	^{134}Cs
^{137}Cs	^{137}Cs
^{60}Co	^{60}Co
^{103}Ru	^{103}Ru
^{106}Rh(Ru)	^{106}Rh(Ru)
	^{141}Ce
	^{144}Ce
	^{110m}Ag
	^{46}Sc

Not a fission product – other source?

Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO Preparatory

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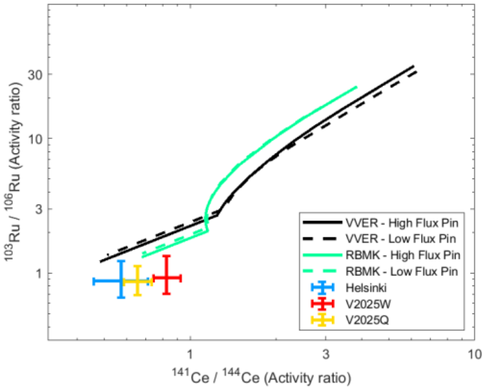
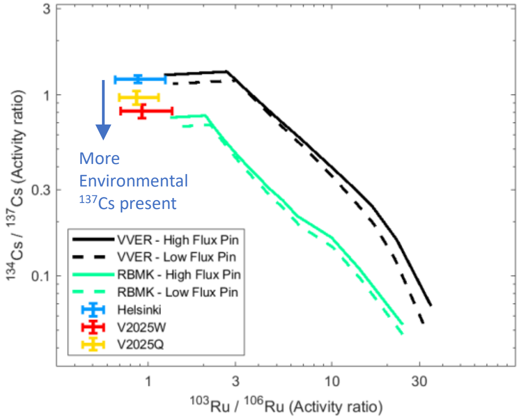
RESULTS

Reactor modelling

- Cs ratios most diagnostic, but problems with other background sources.
- Helsinki had purest Cs ratio, typical historical ^{137}Cs background in Visby is sufficient to cause observed ratio shift.
- All other combinations of ratios were examined (^{103}Ru, ^{106}Ru, ^{95}Nb, ^{95}Zr, ^{137}Cs, ^{134}Cs, ^{144}Ce, ^{141}Ce)
  - Ratio analysis was consistent with a VVER source
  - Most probable VVER discharge time was 55 days prior to arbitrary reference time (July 1, 2020) or early May.
  - ^{46}Sc source is not a fission product – only industrial applications – typically used in hydraulic fracking as a tracer





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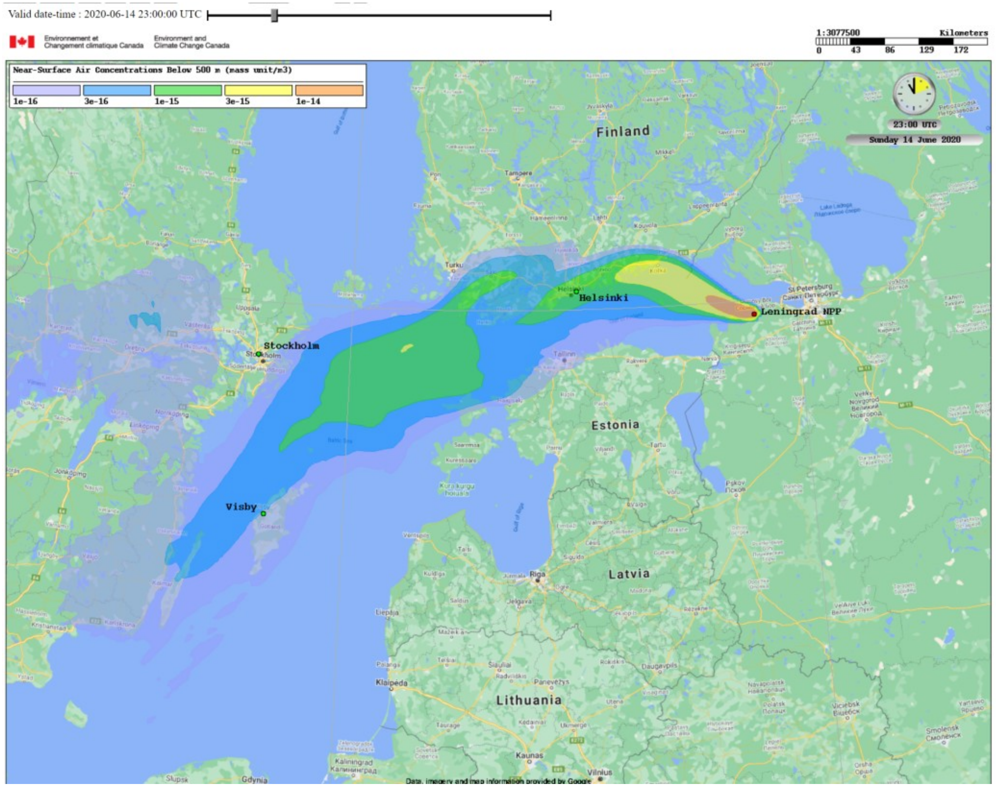
RESULTS

Modelling atmospheric transport forward and backward from detection locations

- Various sources considered:
  - VVER (Leningrad, Kalinin, Kotka)
  - RBMK (Leningrad, Smolensk)
  - Research facilities (Kurchatov, Aleksandrov Scientific Research Technological Institute (NITI), Petersburg Nuclear Physics Institute)
- ^{137}Cs seen relatively often in Kotka, Stockholm, Visby, Helsinki



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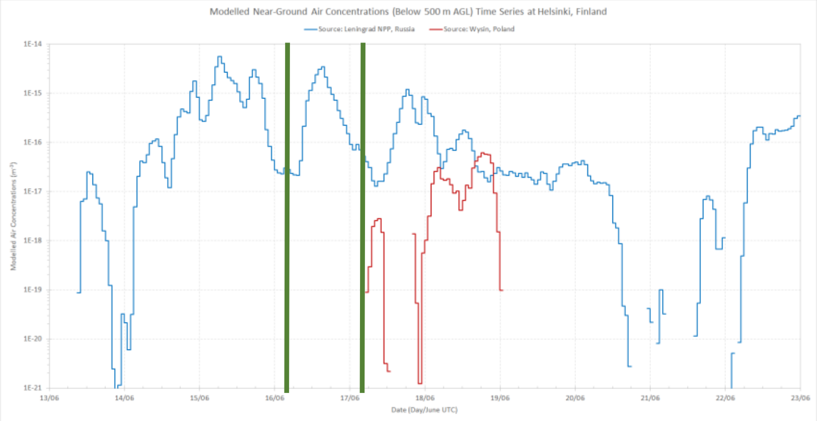
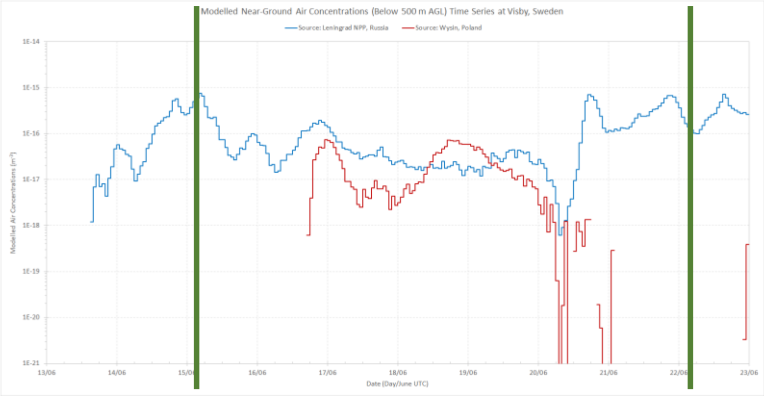
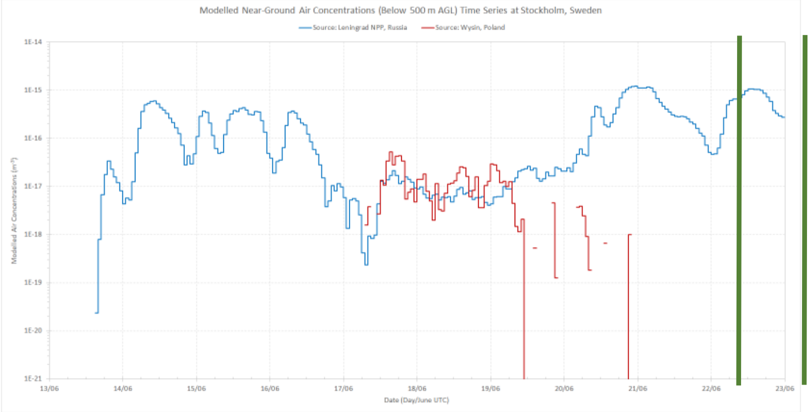
RESULTS

- Forward ATM with sampling intervals marked in green from Leningrad NPP and Northern Poland – most recently hydraulic fracking campaign was in 2016 (https://doi.org/10.1038/s41598-018-26970-9).
- ^{46}Sc producers in Poland (https://www.polatom.pl/en/nasze-produkty) and elsewhere







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CONCLUSIONS

- Two possible VVER sources: Leningrad and Kalinin
    - However, most likely source was the Leningrad Nuclear Power Plant facility (favourable transport)
        - Rosatom EMERCON Report (Sampling period 2020-05-25 to 2020-06-26)
        - Kalinin requires too large a source term
- ^{46}Sc is used as a hydro-fracking tracer and manufactured in Poland, but there may be other sources. Tax-free gas extraction was possible until end of 2020
    - https://www.industryweek.com/the-economy/article/21962431/shale-gas-extraction-taxfree-in-poland-through-2020

Place	Nuclide Concentration (uBq/m3)			
	Co-60	Ru-103	Cs-134	Cs-137
Leningrad NPP (Sosnovy Bor)	< 0.56	1.3±0.4	2.6±0.8	13±4