Assessing the source of anomalous caesium-137 detections across Europe in September 2024

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INTRODUCTION AND MAIN RESULTS

In early September 2024, the particulate radionuclide IMS station in Stockholm, Sweden, observed several anomalous detections of caesium-137. Similarly, unusual detections were simultaneously observed on national monitoring networks across Europe. This poster details a comparison of two source reconstruction tools used to determine a set of likely release parameters associated with the anomalous detections. The calculated release location coincides well with the occurrence of wildfires within the Chernobyl Exclusion Zone. Discrepancies in other source parameter estimates suggests a need for further work to determine the true release profile, which is likely to be non-uniform.

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European caesium-137 detections

In September 2024, the International Monitoring System (IMS) particulate station in Stockholm, Sweden observed caesium-137 (^{137}Cs) above typical background levels. Simultaneously, national monitoring networks within the "Ring of Five" (Ro5) also began to report trace amounts of ^{137}Cs in filtered air samples. Locations of known detections are shown in Figure 1. This work aims to compare the outputs of two tools used to determine the likely source parameters associated with the detections.

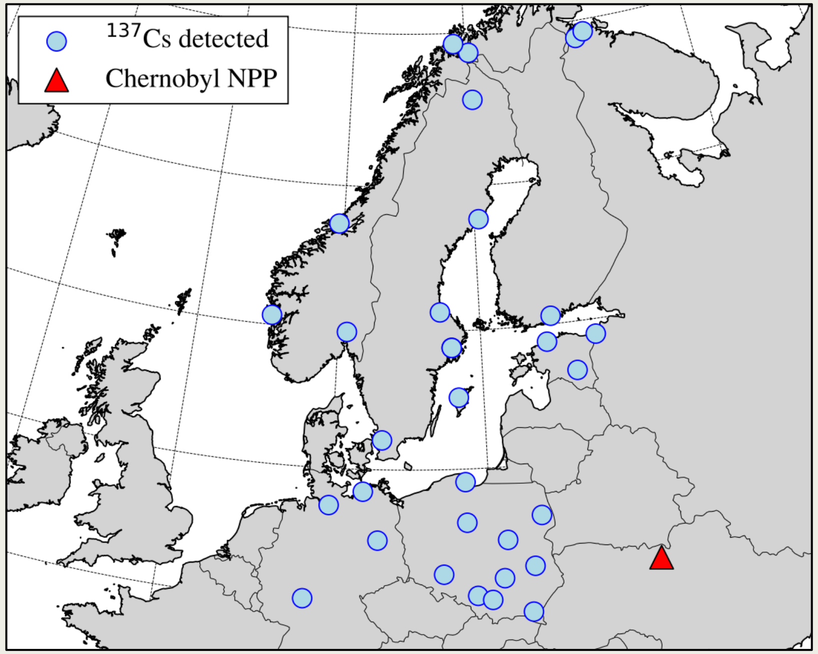

Figure 1. Sampling locations for detections of ^{137}Cs above the minimum detectable concentration (MDC) between 1st – 16th September 2024. Collection periods vary from daily to weekly.

Atmospheric transport & dispersion modelling

Inverse atmospheric transport and dispersion modelling (ATDM) was performed using both HYSPLIT, developed by the National Oceanic and Atmospheric Administration (NOAA), and the Numerical Atmospheric-Dispersion Environment (NAME), developed by the UK Met Office. Model input parameters are shown in Table 1.

Table 1. ATDM input parameters.

Meteorological Data	
Horizontal resolution [º]	1.0 x 1.0
Temporal resolution [hours]	3
ATDM Parameters	
Number of particles [per hour]	5,000
Vertical layer depth [m]	150
Sample horizontal grid [º]	0.5 x 0.5
Sample temporal frequency [hours]	3
Run duration [days]	7

Source reconstructions

Observations and their respective source receptor sensitivity (SRS) fields can be combined to calculate a set of optimal source parameters. Two reconstruction tools have been utilised for the comparison: *Forensic Radionuclide Event Analysis and Reconstruction* (FREAR, developed by the Belgian National Data Centre (NDC) and Health Canada) [1]; and the *Unknown Source Inversion* tool (developed by the UK Met Office) [2]. Prior domains are shown in Table 2. Both tools used Bayesian inversion techniques and assumed a discrete release of radionuclides within the given temporal domain.

Table 2. Source reconstruction input parameters.

Spatial Domain	
Minimum latitude [º]	32
Maximum latitude [º]	72
Minimum longitude [º]	7
Maximum longitude [º]	46
Temporal Domain	
Release start time [UTC]	01-Sep-2024
Release start time [UTC]	12-Sep-2024
Magnitude Domain	
Minimum [total GBq]	0.1
Maximum [total GBq]	1000

Results – *Unknown Source Inversion*

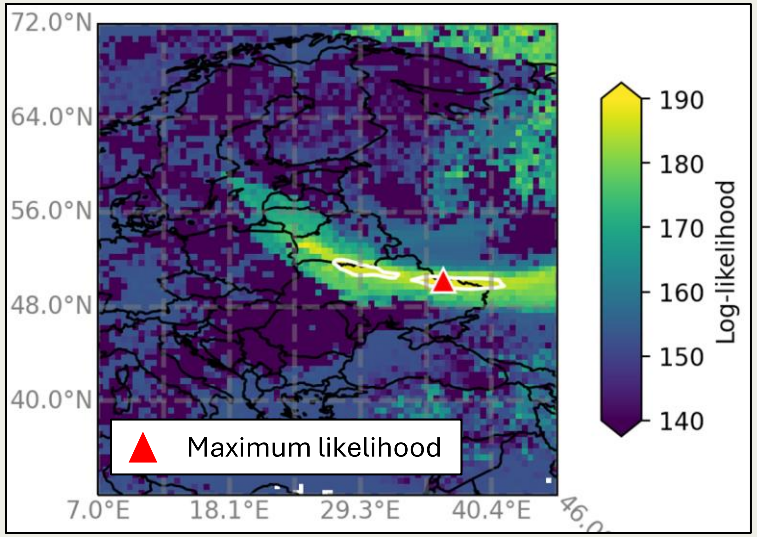

Figure 2. Most likely source location distribution calculated using the *Unknown Source Inversion* algorithm.

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Results – *Unknown Source Inversion* (cont.)

Table 3. Most likely source parameters calculated by the *Unknown Source Inversion* algorithm.

Source Parameter	Optimised Estimate
Total magnitude [GBq]	56
Release start time [UTC]	00:00 05-Sep-2024
Release stop time [UTC]	00:00 07-Sep-2024

Results – *FREAR*

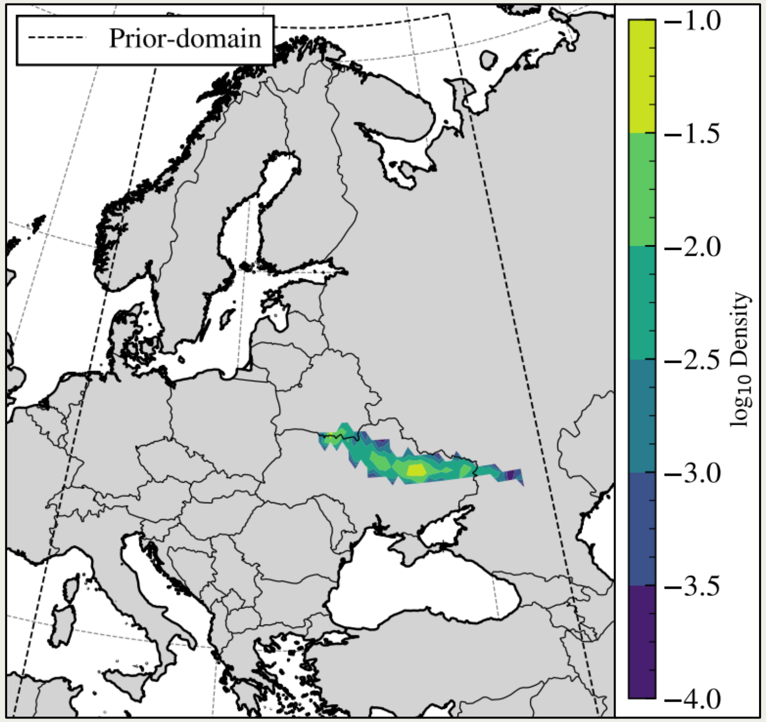

Figure 3. Most likely source location distribution calculated using FREAR.

Table 4. Most likely source parameters calculated by FREAR.

Source Parameter	Optimised Estimate
Total magnitude [GBq]	3
Release start time [UTC]	00:00 03-Sep-2024
Release stop time [UTC]	00:00 10-Sep-2024

Discussion

Figures 2 and 3 show that both methods suggest the most likely source location is somewhere in Eastern Europe. The bulk of the distributions cover the Chernobyl Exclusion Zone (CEZ), as well as an area to the east of this location. There are discrepancies between the remaining source parameter estimations, with FREAR suggesting a smaller total release of material over a longer period in comparison to the *Unknown Source Inversion* tool. Differences could be attributed to a variety of factors including the atmospheric transport models themselves – this is an area for further investigation.

Wildfires – Chernobyl Exclusion Zone

The Chernobyl nuclear disaster dispersed a significant amount of ^{137}Cs into the environment, the majority of which was deposited within an area close to the event. Resuspension of material from within the resulting exclusion zone (for example, due to high winds) often causes low level detections on monitoring systems. In September 2024, wildfires within the CEZ (approximately 50-56 km west of the Chernobyl Nuclear Power Plant) were reported following a period of drought conditions [3]. Aerosolisation of deposited material due to the wildfires has been attributed to the IMS and Ro5 ^{137}Cs detections [4]. Ground truth information for the extent of the wildfires has been determined using satellite imagery (see Figure 4).

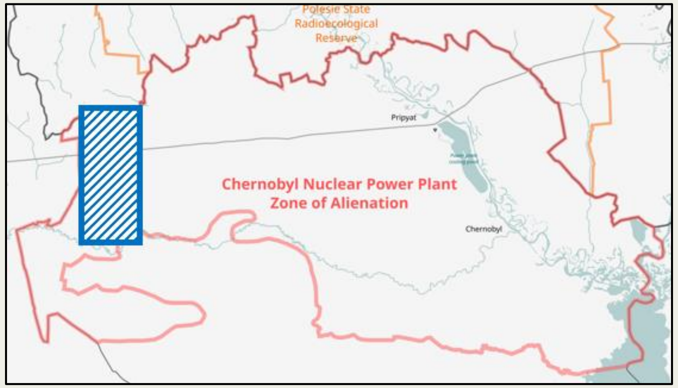

Figure 4. Map showing the CEZ and the extent of the wildfires in September 2024 (hatched area, as determined by satellite imagery). Adapted from [5].

The ground truth release location lies within the estimations provided by both source inverse tools. The fires reportedly began in late August 2024 and were largely extinguished as of 12th September 2024 [3]. The non-uniform distribution of ^{137}Cs contamination within the area affected by the wildfires means that the associated release profile is also likely to be non-uniform – more work could be done to determine this.

1. De Meutter, P., Hoffman, I., Bayesian source reconstruction of an anomalous Selenium-75 release at a nuclear research institute (2020) J. Environ. Radioact., 218, 106225, ISSN 0265-931X, https://doi.org/10.1016/j.jenvrad.2020.106225
2. Western L.M., Millington, S.C., Benfield-Dexter, A., Witham, C.S., Source estimation of an unexpected release of Ruthenium-106 in 2017 using an inverse modelling approach (2020), J. Environ. Radioact., 220–221, 106304, ISSN 0265-931X, https://doi.org/10.1016/j.jenvrad.2020.106304
3. https://www.radenviro.ch/forest-fires-in-the-chornobyl-exclusion-zone-update-october-2024/?lang=en
4. https://www.reuters.com/world/europe/russia-has-not-issued-any-alerts-elevated-radiation-atmosphere-kremlin-says-2024-09-18/
5. *Nzeemin - Own work, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=19091920*

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