

1 Introduction

- On May 15th, 2019, an incident in a hot cell at the Belgian Reactor 2 (BR2) on the SCK CEN campus in Mol led to the accidental release of radioactive selenium-75 (Se-75) into the atmosphere.
- Previous investigations by Frankemölle et al. (2022) examined both the source term reconstruction and local-scale dispersion of Se-75, employing a Gaussian dispersion model to simulate the local puffs.
- This study leverages this well-characterized release event to evaluate uncertainty quantification in atmospheric dispersion modelling, with a specific focus on mitigating ensemble under-dispersion in short-range simulations.
- A multi-model and a multi-meteorological input approaches are used to produce ensemble simulations, and the impact of these approaches on the spread of the ensemble is discussed.

2 Methodology

- The observations come from an array of gamma dose rate detectors monitoring the vicinity of the BR2 facility (see Figure 1).
- Two dispersion models are employed: **FLEXPART** and a **Gaussian plume** model with Pasquill-Gifford and Briggs parametrization.

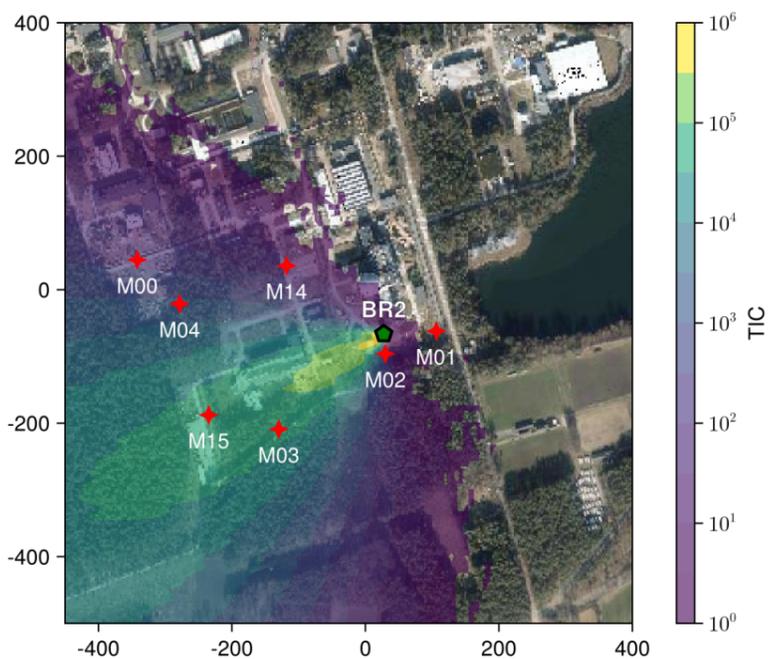


Figure 1. Time Integrated Concentration (TIC) [Bq s/m³] of the FLEXPART deterministic simulation in the vicinity of the release, with the locations of the gamma dose rate detectors and the BR2 facility. The spatial unit is in meter.

- The dispersion models were driven by meteorological inputs from the Ensemble Prediction System (EPS) of ECMWF. It comprises 50 ensemble members available at 3-hourly intervals, each serving as input for separate dispersion simulations with both models.
- The ensemble size is further increased by using 5 forecasts separated by 12 hours initialization time, to finally reach 250 ensemble members per model.
- From this ensemble, various statistical metrics are derived: ensemble mean, ensemble spread (quantified as the standard deviation from the mean) and coefficient of variation (defined as the ensemble standard deviation normalized by the mean).

3 Results

- Figure 2 presents the ensemble dispersion simulation results at 4 stations.
- The results demonstrate consistently greater ensemble spread in the Gaussian plume model compared to FLEXPART, indicating higher sensitivity to meteorological variations with this model.
- Interestingly, the highest uncertainty occurs at IMR/M02, a station initially excluded from the previous analysis because the plume detection was not clear enough.
- We observe that the measurements often falls outside of the standard deviation zone, which means a potential under-dispersiveness of the ensemble (but there is also a high uncertainty in the measurements).

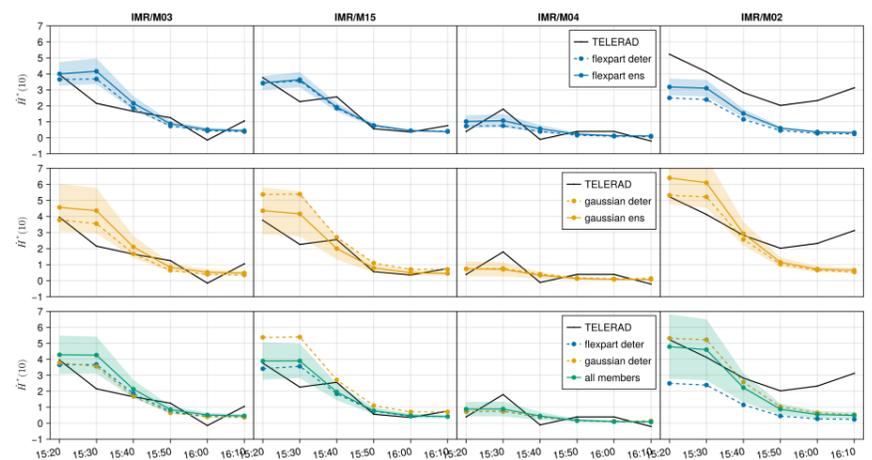


Figure 2. Comparison of background-subtracted ambient dose equivalent rates (in nSV/hour) between TELERAD measurements and ensemble simulations. Black solid lines represent TELERAD measurements, while dashed lines show deterministic simulation results. Ensemble means are depicted as solid coloured lines with shaded bands indicating the ensemble spread (± 1 standard deviation).

- To evaluate the influence of forecast lead time on ensemble uncertainty, Figure 3 shows the time- and station-averaged coefficient of variation.
- We see a systematic increase in Ensemble Dispersion Model (EDM) uncertainty with longer lead times, a trend that generally correlates with the rising uncertainty in the ECMWF wind speed ensemble. However, the correlation is not strictly linear.
- The spread is further increased when considering a multi-model approach.

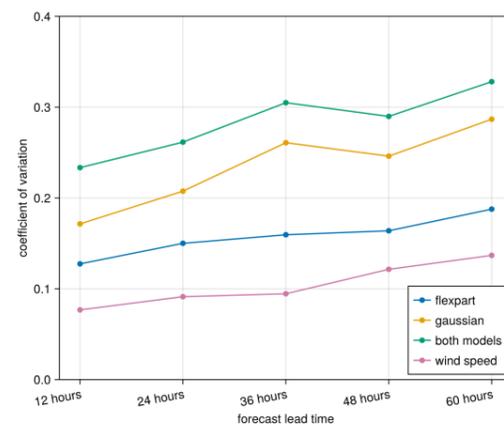


Figure 3. Temporal and spatial average of the ensemble coefficient of variation across all valid detection stations as a function of forecast lead time.

4 Conclusions

- It is shown that both approaches for enhancing the ensemble spread in case of short scale event are effective.
- The ensembles still appears under-dispersive, and future work should determine whether spread continues to increase with additional members or eventually reaches an asymptotic limit.
- The limited observational dataset ($n=24$) precluded robust quantitative evaluation using standard metrics like rank histograms or RMSE. Future studies could assess the impact on the predictive skill of this methodologies, but this would require a more extensive dataset.

