Quantifying uncertainties in air pollutant exposure modelling from accidental point releases,

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Motivation

- In emergency response or/and associated risk assessment, exposure quantification is essential in terms of :
- **expected value (ensemble average, most probable),**
- **associated uncertainties**

IDEALLY

Quantify exposure in terms of pdf/cdf

Exposure Modeling Uncertainties

- Uncertainties due to wind variability
- Uncertainties due to modeling approach and numerics
- exposure time induced inherent uncertainties

From past experience :

- the wind direction uncertainty seems to be of major importance

The Present General Problem

Consider a continuous point source with a constant release rate

Problem 1:

Assume the source release rate as known and predict exposure related parameters and associated uncertainties at selected positions downstream

Problem 2:

Assume the source term unknown and predict the source release rate and its uncertainty from exposure related parameter signals at specific positions downstream.

The new approach

- **THE OBJECTIVE**
  - the whole approach to be relatively simple with substantially low computational time even for complex problems with the aim to be manageable by the user even at operational level.

- **THE BASE**
  - direct use of the **real signals** (or/and model pdf) concerning wind speed and direction or/and exposure related parameters.
  - restrict computation to steady state **reference** wind speed and source term conditions
  - adopt to real conditions via **proper scaling** reflecting current expertise and
  - treat relevant parameters involvement via respective pdf **creating a novel tool** for this purpose

- **A FIRST APPLICATION :**
- **THE RADIOLOGICAL MOL EXPERIMENT**

The real-scale MOL experiment

- Routine releases of ^{41}Ar from the 60-m high stack of the BR1 research reactor at the Belgium Nuclear Research Centre (SCK•CEN, Mol); constant release rate 4.27×10^7 Bq/s
- Radiation measured near ground at downwind distances up to 1500m from the release point, by sensors in arrays perpendicular to main advection direction
- Dates of the experiment:
  - Wed 3/10/2001
  - Thu 4/10/2001
  - Fri 5/10/2001

The real-scale MOL experiment (2)

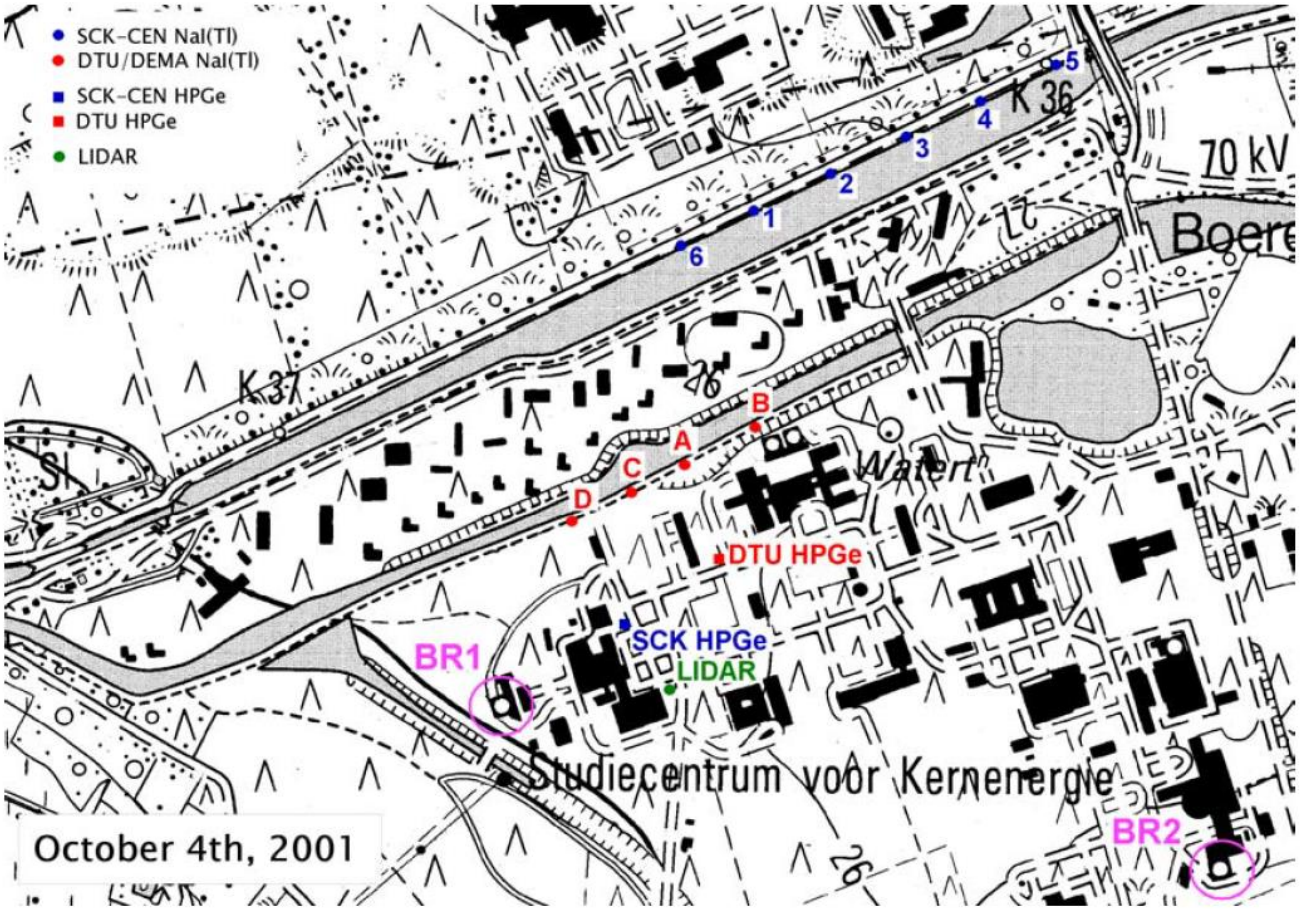
- Available radiation measurements:
  - Fluence rate at 1-min resolution by 4 NaI(T1) detectors of the Danish Emergency Management Agency (DEMA)
  - Counts per sec at 1-min resolution by 4 NaI(T1) detectors of the SCK•CEN
  - Fluence rate at variable time resolutions by Germanium detector of the Danish Technical University

The real-scale MOL experiment (3)

- Meteorological measurements:
  - From SCK•CEN weather-mast
  - At 1-min resolution:
    - Wind speed at 24, 69, 78, 114 m
    - Wind direction at 24, 48, 69, 114 m
    - Air temperature at 8 m
  - At 10-min resolution
    - Wind speed at 69, 78 m
    - Wind direction at 69 m
    - Air temperature at 8, 24, 48, 78 114 m
    - Pressure
    - Atmospheric stability class

The MOL Experiment Layout (4/10/01)

M. Drews, H. K. Aage, K. Bargholz, H. Jørgensen, U. Korsbech, B. Lauritzen, T. Mikkelsen, C. Rojas-Palma and R. Van Ammel, Measurements of plume geometry and argon-41 radiation field at the BR1 reactor in Mol, Belgium, Report NKS-55, ISBN 87-7893-109-6, February 2002



The MOL Experiment: The present Application - DATA

- The study time interval : 4 Oct, 10:18 – 16:00
- Source release rate : 4,27e+07 Bq/s
- Wind speed and direction 1 min signals at 69 m height
- Fluence rate 1 min signals from the 4 NaI(T1) detectors {Horizontal distance from the source : [sensor A: 344 m sensor B: 433 m sensor C: 287 m sensor D: 231 m]}

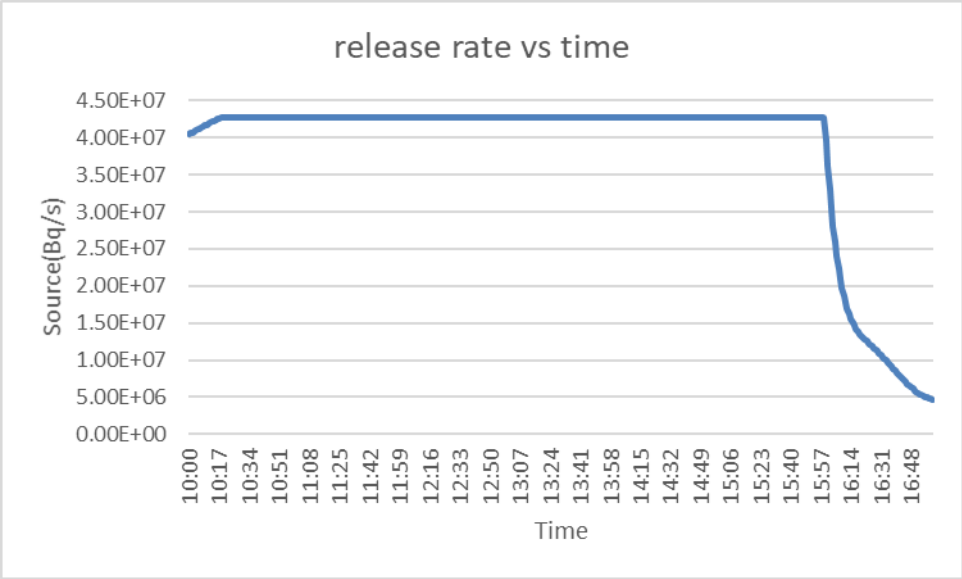
The MOL Experiment: The present Application= MODELING

- A simple Gaussian model is used to model pollutant dispersion.

- In the model, the fluence rate is estimated following Andronopoulos and Bartzis (2010) and Gorshkov et al. (1995).

The Mol Experiment

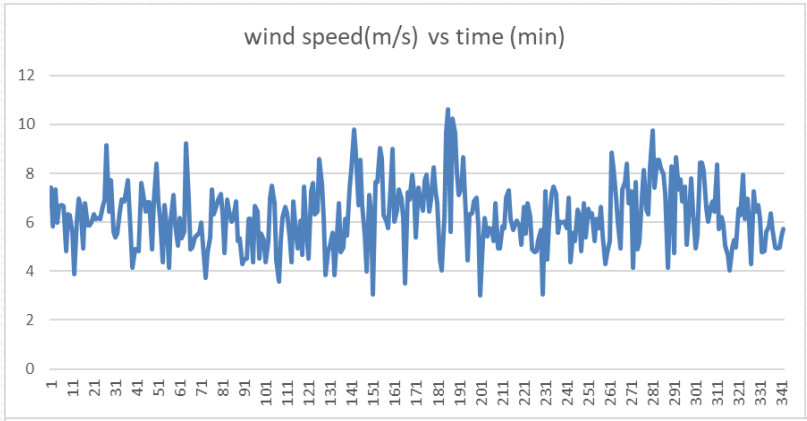
The source measured at height 60m

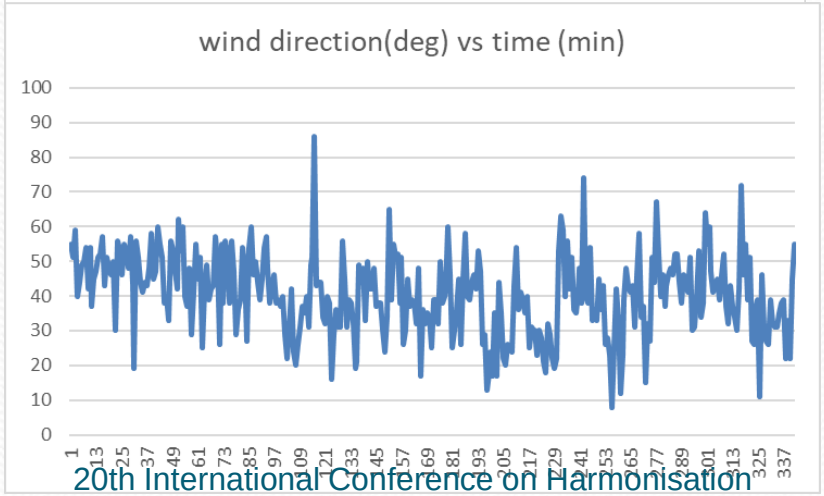


The study time interval : 4oct, 10:18 – 16:00

The Mol Experiment

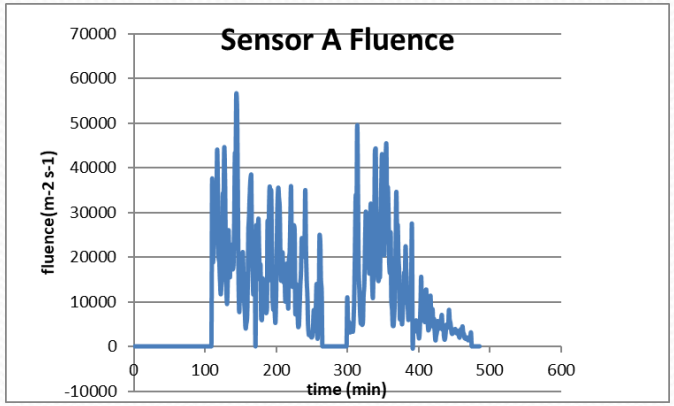
The wind time series(height 69m) with time resolution Δτ=1 min

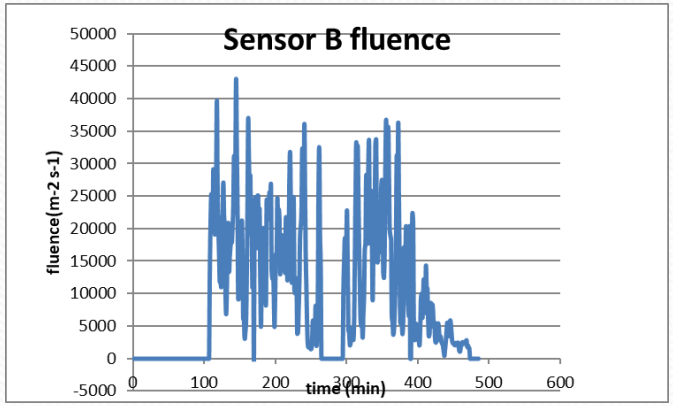


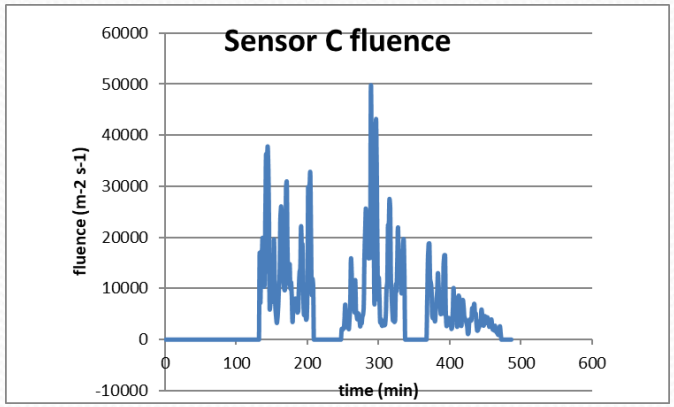


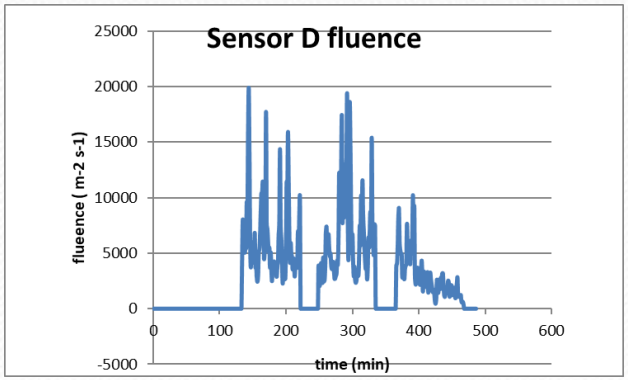
The Mol Experiment

Sensors Fluence rate(m-2 s-1) with a time resolution Δτ =1 min









The Mol Experiment
The two modeling problems

Problem 1 :

Assume the source release rate as known .

Predict fluence rates at the four sensors and compare with the measured values

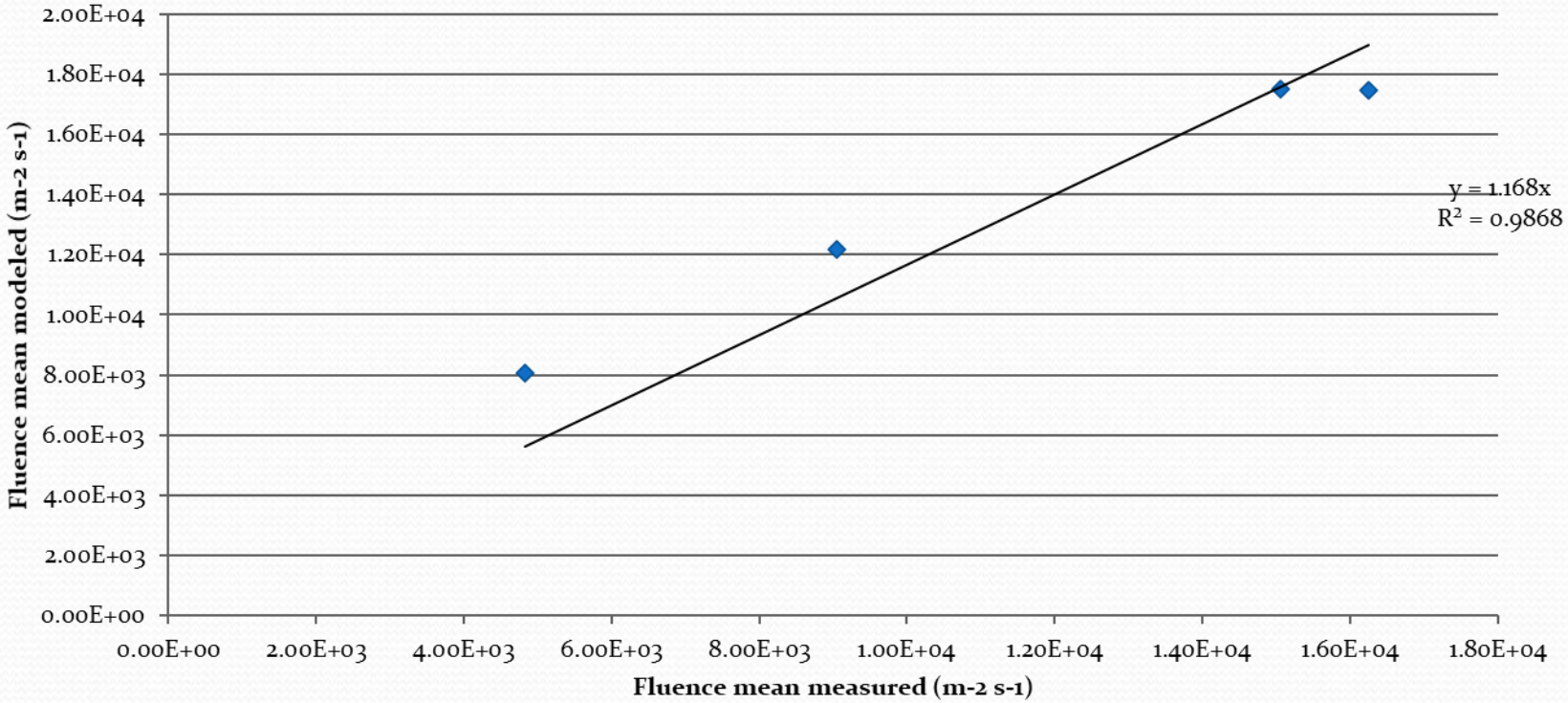
Problem 2

Assume the source release rate as unknown.

Predict the source release rate from the four(4) fluence rate signals

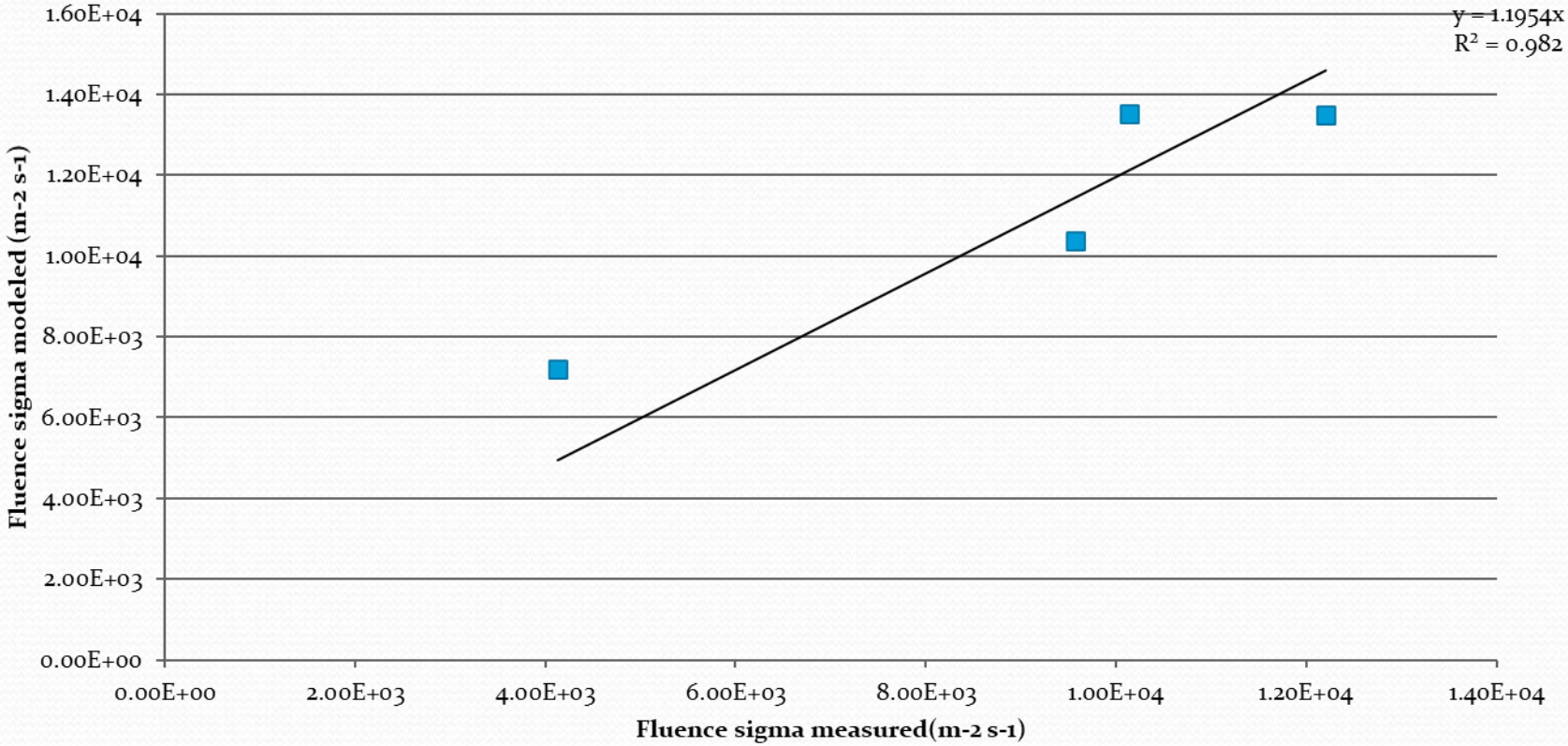
The Mol Experiment Problem 1

Fluence mean values comparisons



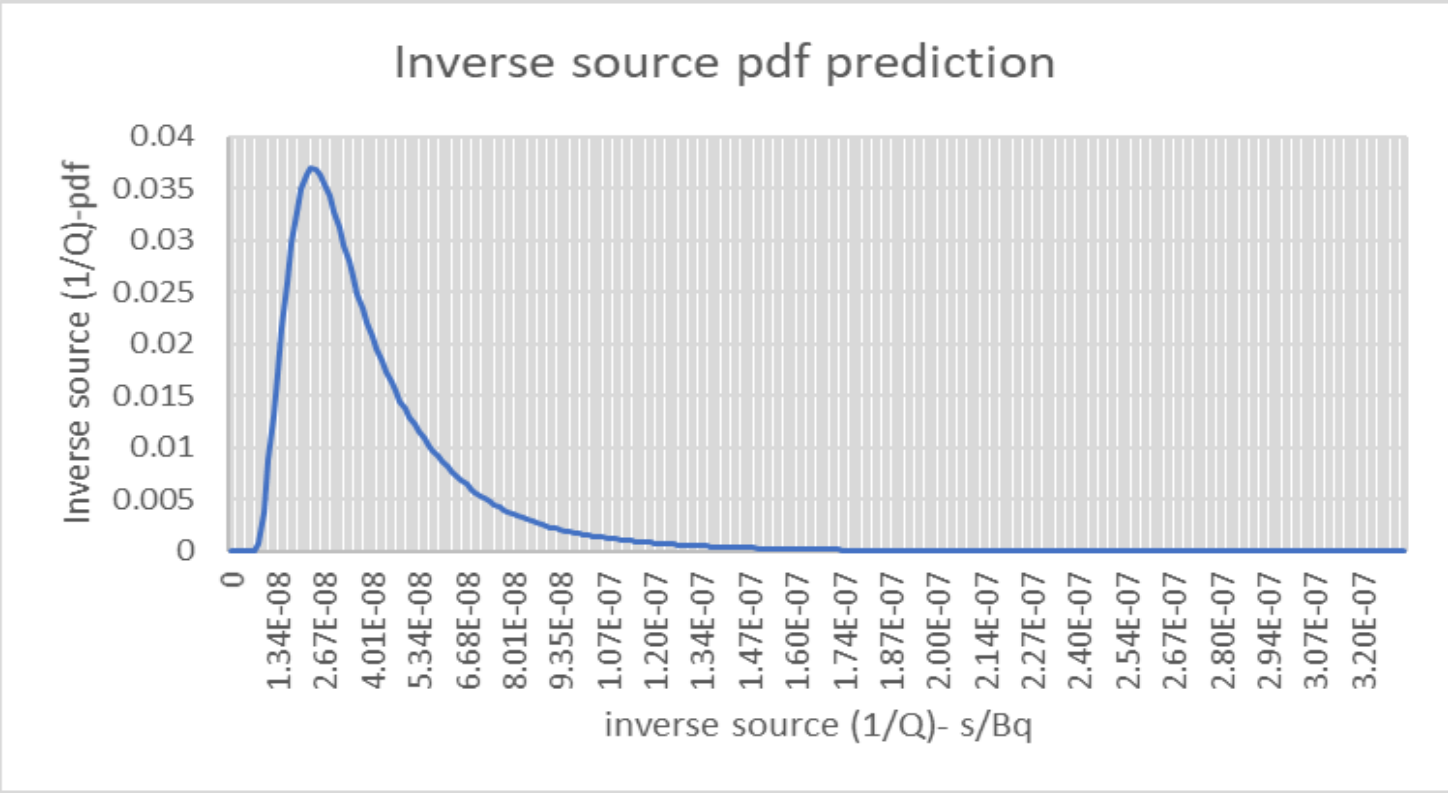
The Mol Experiment Problem 1

Fluence standard deviation comparisons



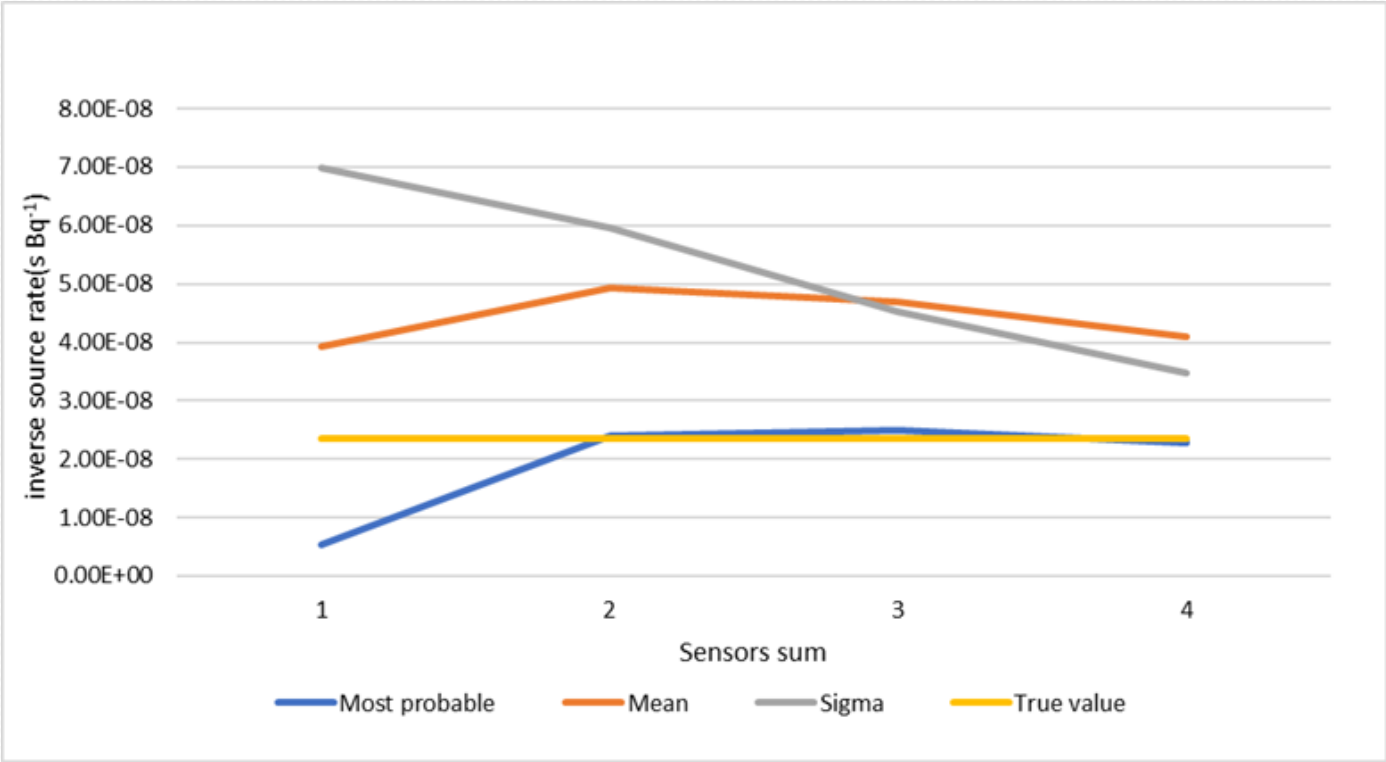
The Mol Experiment Problem 2

The source release rate prediction



The Mol Experiment Problem 2

Inverse source term prediction vs number of sensors involved



Concluding Remarks

- Searching for more practical approaches , the exposure quantification in terms of expected value and its uncertainties has been put in a new basis.
- Applying this new concept in the Mol experiment – an experiment under real environmental conditions- the comparison results went beyond expectations!
- It is noticed that the new concept indicates its advantage as the method to predict the source term
- The whole approach is under development and the present application is pressing to go forward.

Acknowledgements

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Ευχαριστώ
Thank you

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