Estimation of source term released using non-linear regression analysis

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Introduction

- A study was performed to estimate radiological source term by applying non-linear regression method using least-squares of the measured data such as radioactivity concentrations, wind speed, wind direction and atmospheric stability, etc.
- This method was tested for tracer experimental data conducted ay Yong-Gwang nuclear power plant site to obtain the optimized source release rate and horizontal and vertical dispersion factors from the experiment

Objectives

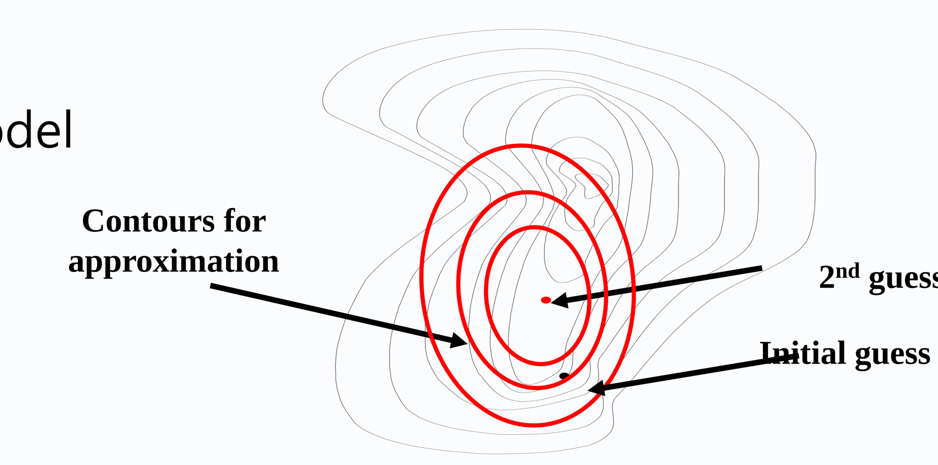
- In case of a nuclear power plant accident, it is not so easy to predict the source term released because of the failure of the internal measurements system
- A useful method is the feedback of the environmental measured data into an analytical radiological consequence modeling near the accident site
- The objective of this study is to predict the source term release rate based on non-linear regression analysis using a simple Gaussian plume model

Methods

- Non-linear regression method
  - ✓ Minimization of differences between measured data and predicted values from the model

$$\frac{\partial \chi^2}{\partial p_j} = \frac{\partial}{\partial p_j}\sum_i \left[\frac{1}{\sigma_i{}^2}(o_i - c_i)^2\right] = 0$$

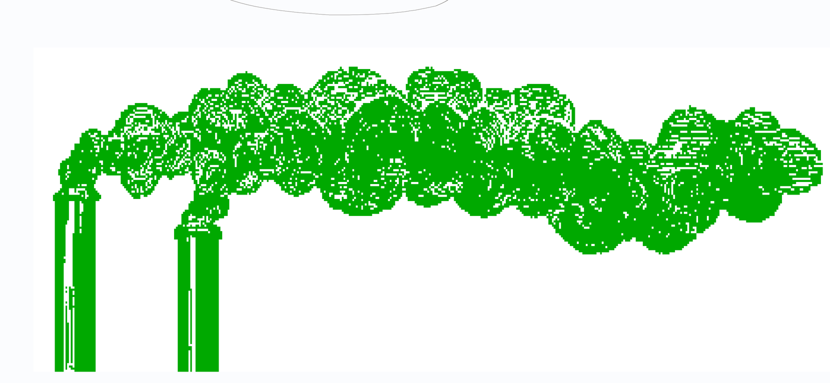
where, $o_i, i = 1,2,\ldots I$ – measured data
$\sigma_i = \sigma(x_i)$ - uncertainty
$p_j, j = 1,2,\ldots J$ - parameters
$c_i = c(x_i, p_j)$ – calculated from model



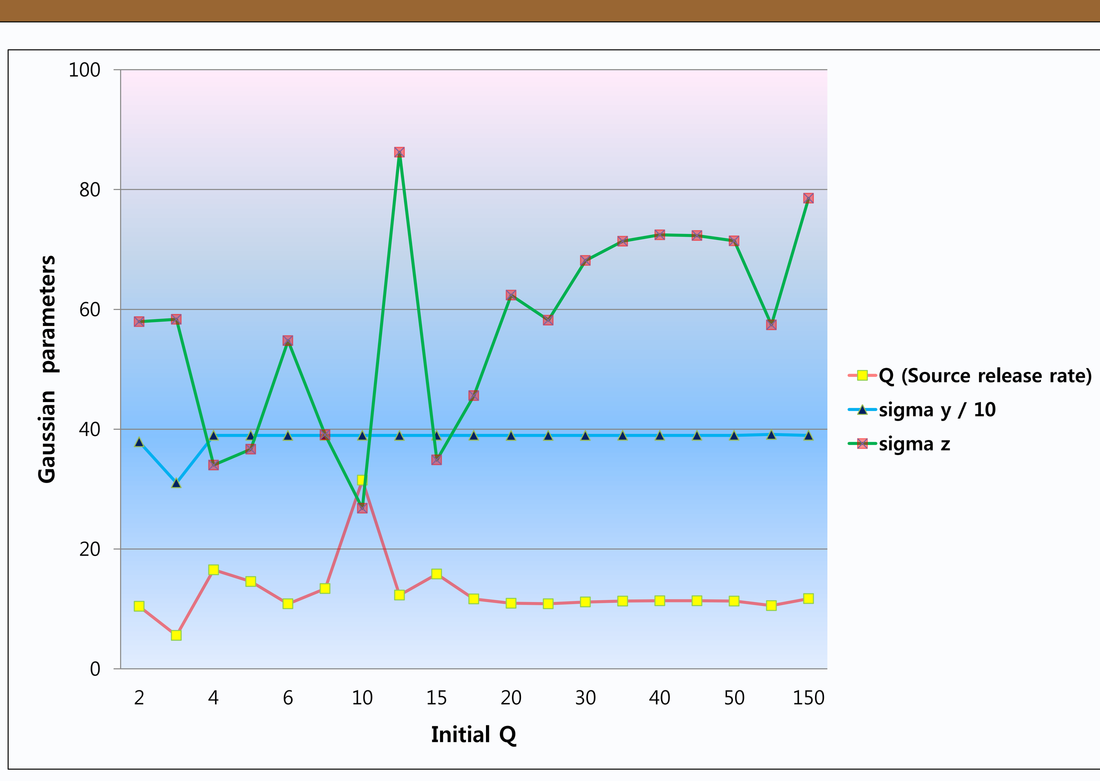
- Gaussian plume model
  - ✓ Estimation model for radiological consequences near power plant site

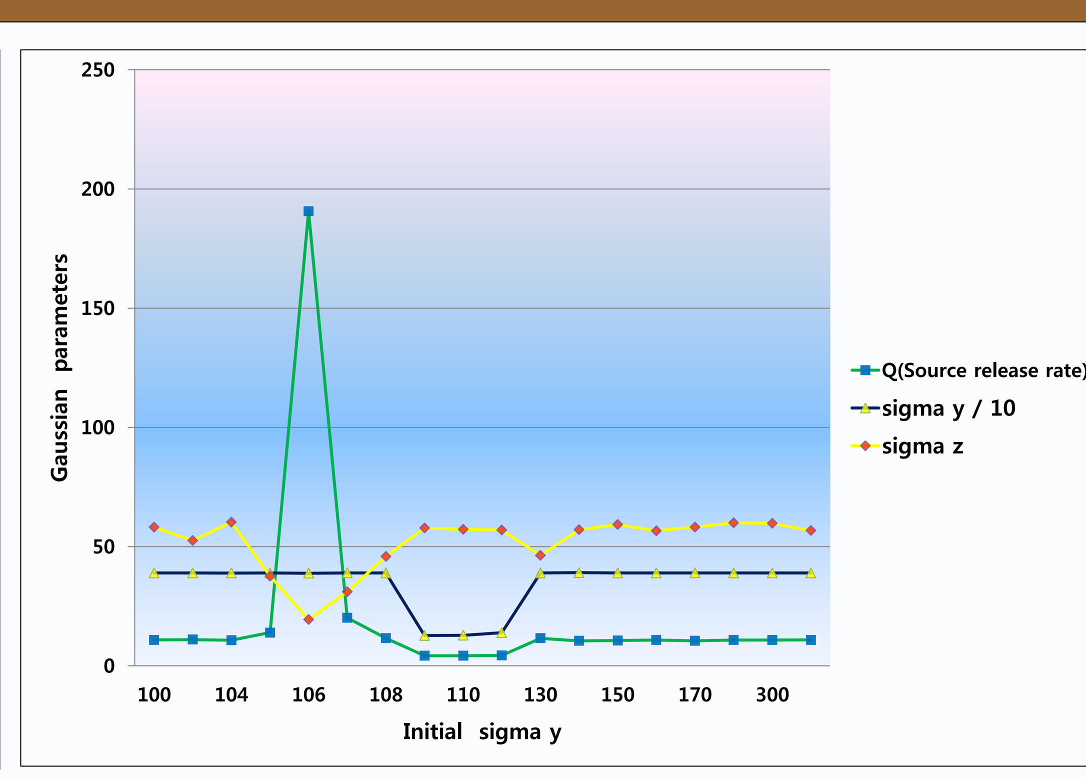
$$X_{air}(x,y) = \frac{Q}{\pi \bar{u}\sigma_y\sigma_z}\exp\left(-\frac{y^2}{2\sigma_y{}^2} - \frac{h^2}{2\sigma_z{}^2}\right)$$

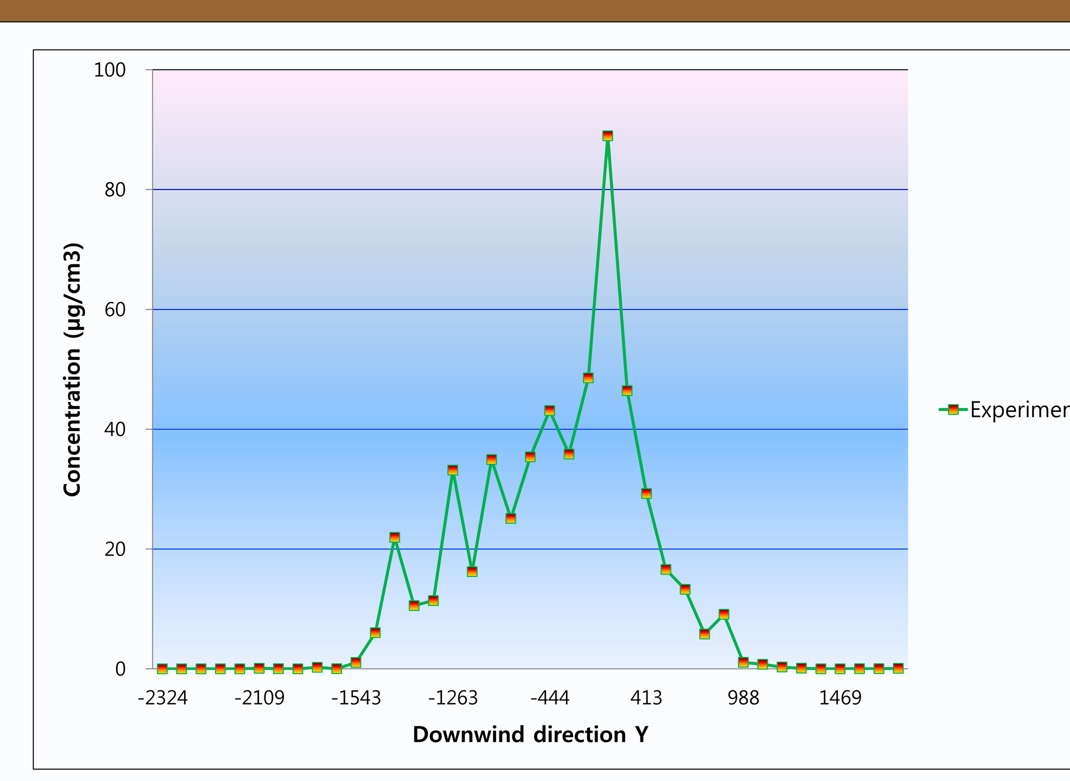
where, $X_{air}(x,y)$ is radiological concentration
Q is source release rate
$\bar{u}$ is average wind speed
σ_y, σ_z is atmospheric stability
h is release height



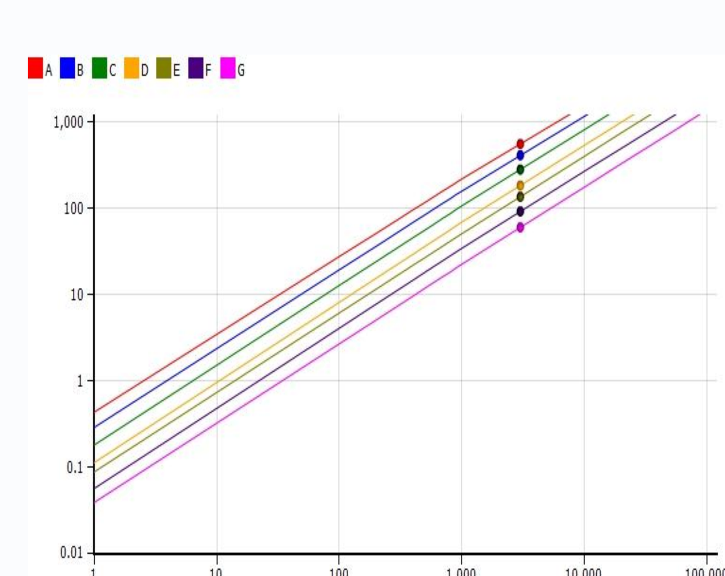
Results

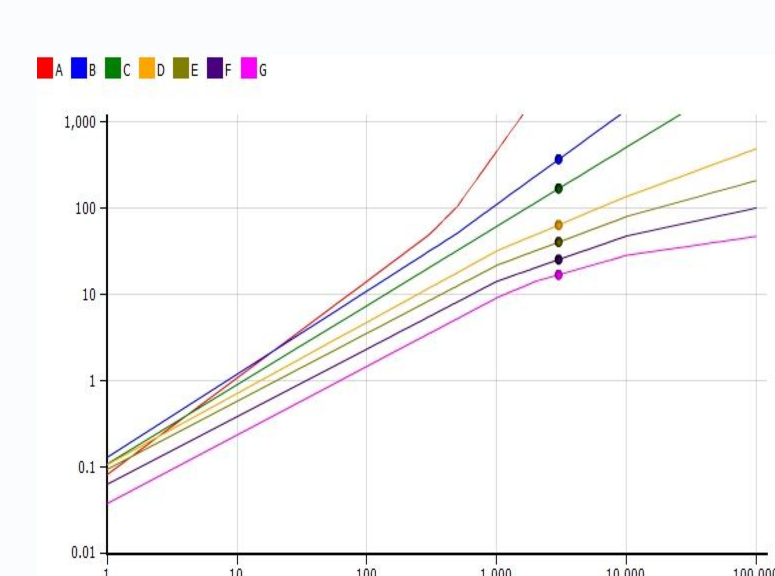






- Non-linear regression method was applied to an experiment in 1996 where data were measured using SF6 gas at 3 km distant from center
- The initial release rate of the gas was 32 g/sec
- The average release rate by calculation is 13.5±6.8 (g/sec) and under-estimated by 40% when compared with the experiment
- By estimation, σ_y, the downwind stability lies between B and C class and σ_z, the vertical stability lies between C and D class at 3 km distance on Pasquill-Gifford graph
- A few calculations show an abnormal peak but most calculations show a good convergence in general





Discussions and Conclusions

- Source release rate can be estimated within acceptable errors by non-linear regression method
- Marquadt method was the most useful relative to the steepest decent method and the expansion method in terms of conversion speed and the calculation stability
- Sensitivity analysis for the atmospheric stability σ_y, σ_z and the source release rate Q shows that the calculation results depend on the initial value and shows a good converge
- More precise estimation of the parameters can be obtained by quantity and precision of the measurement data

13th International Congress of the International Radiation Protection Association, 13-18 May 2012, Glasgow, Scotland