Methods for reducing uncertainty in source term estimation during a nuclear accident

Masamichi Oura, Minsik Kim, Ryohji Ohba, Shinsuke Kato (The University of Tokyo, Japan)
Alan Robins (University of Surrey, UK)
masamich@iis.u-tokyo.ac.jp

1. Uncertainty in wind direction

Wind direction used in a calculation includes observation errors and uncertainty due to use of 16 categorizations of wind direction.

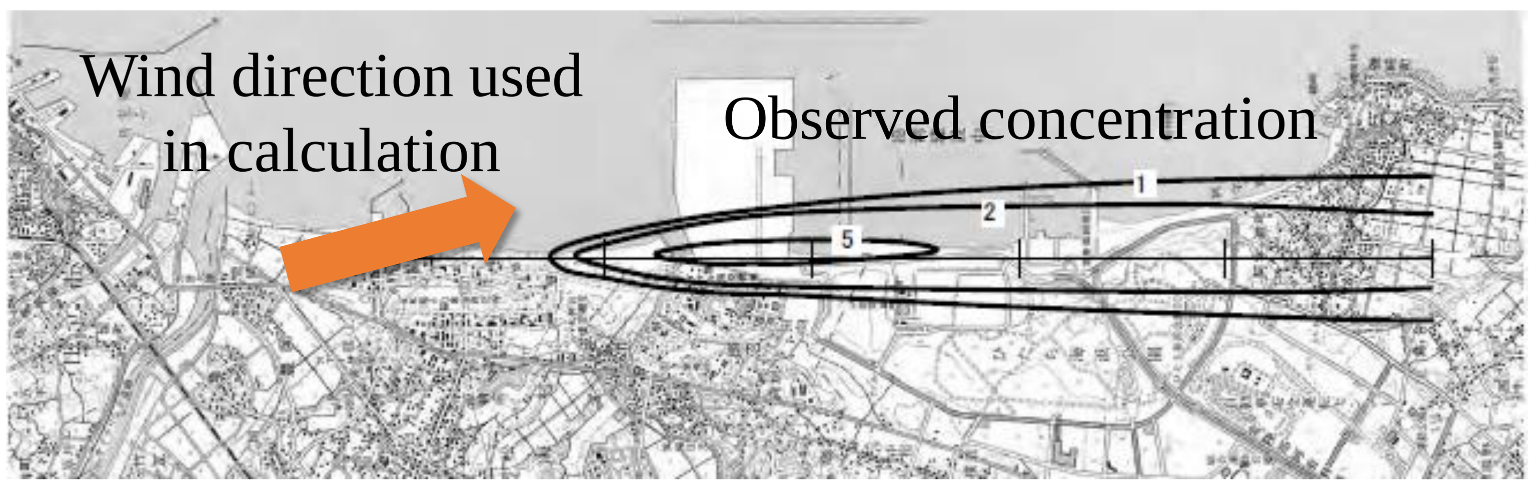
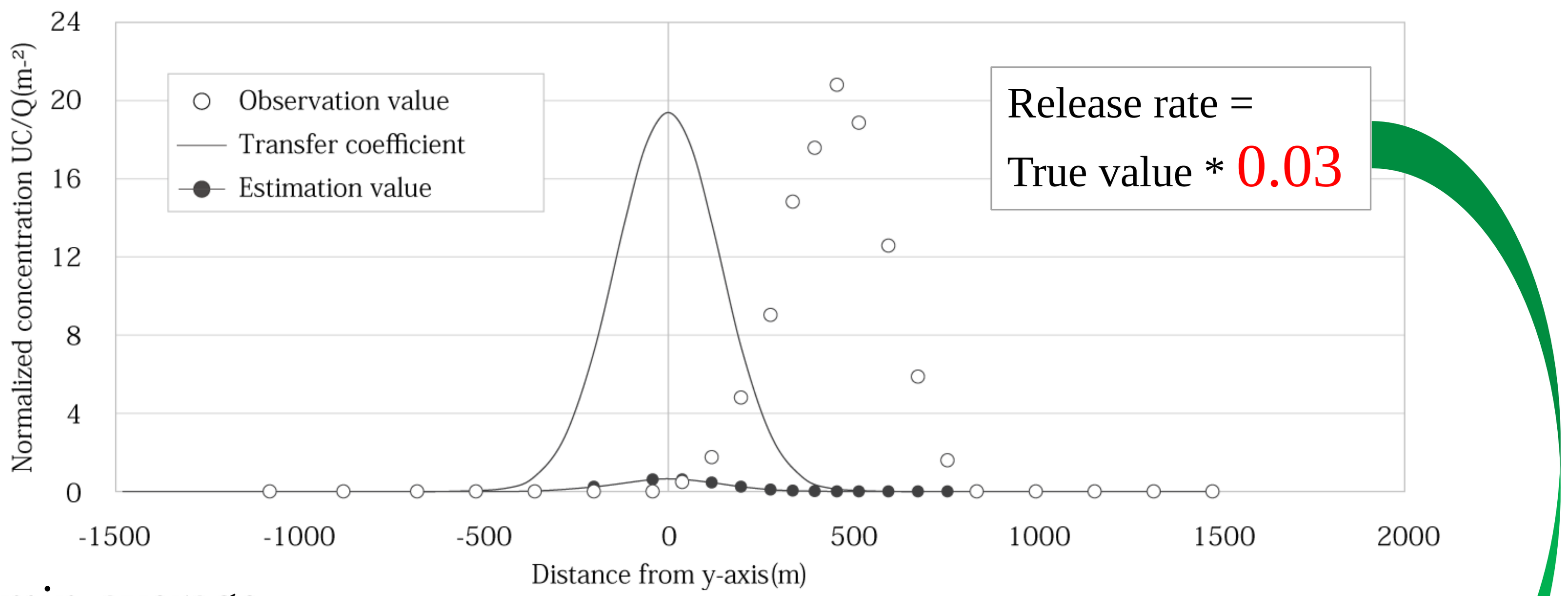


Fig. 1 Observed concentration distribution and wind direction in calculation

The accuracy of source intensity estimation was found to be noticeably improved by use of increased averaging times because lateral plume spread increases with averaging time of observations, as shown in Fig. 2.

a) 3min-average



b) 60min-average

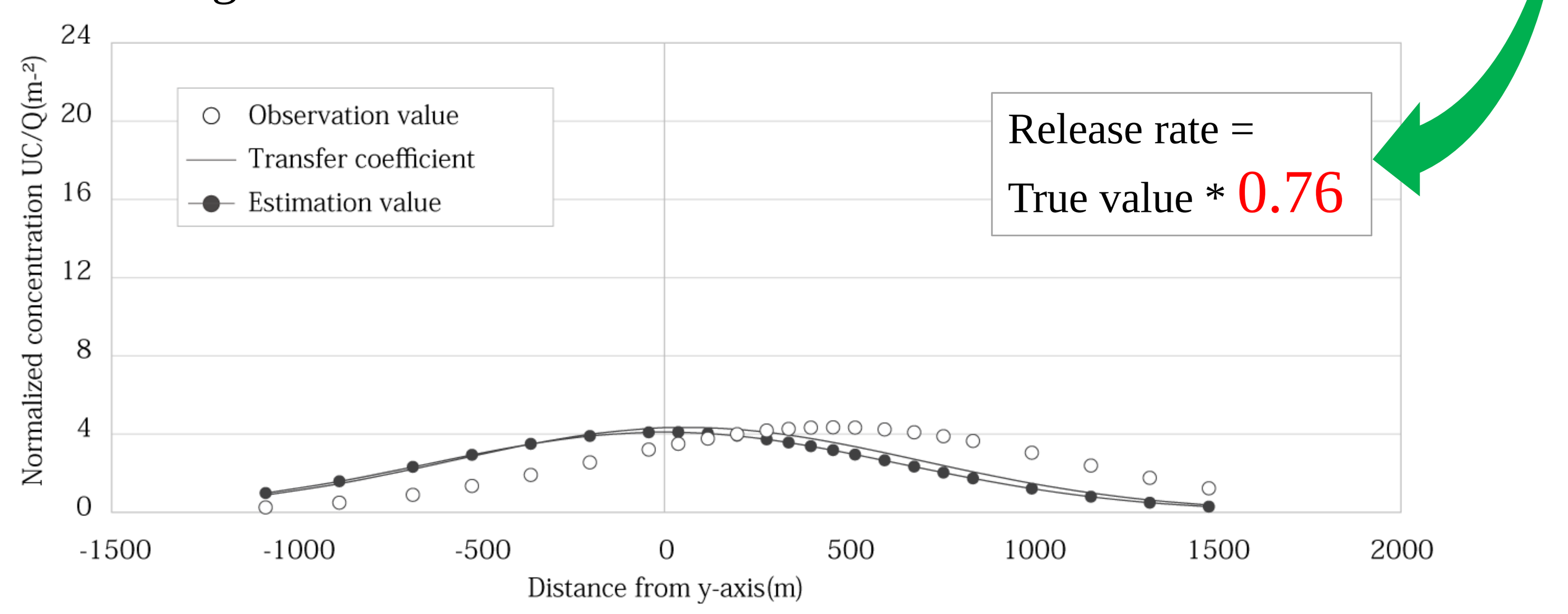


Fig.2 Lateral concentration distributions at downwind distance of 2000m

2. Uncertainty in plume axis position due to terrain effects

Drift of plume axis caused by complex terrain

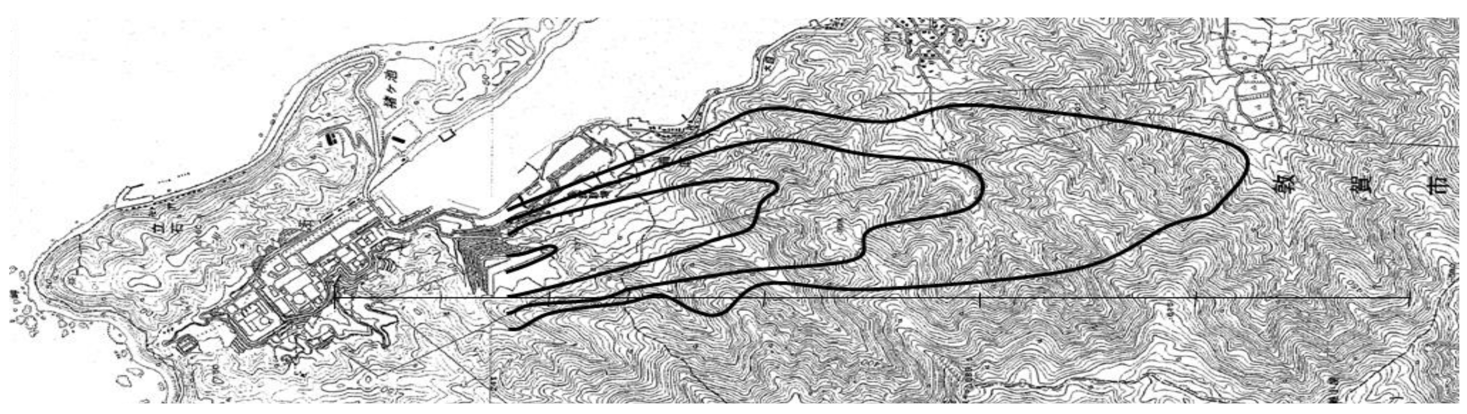
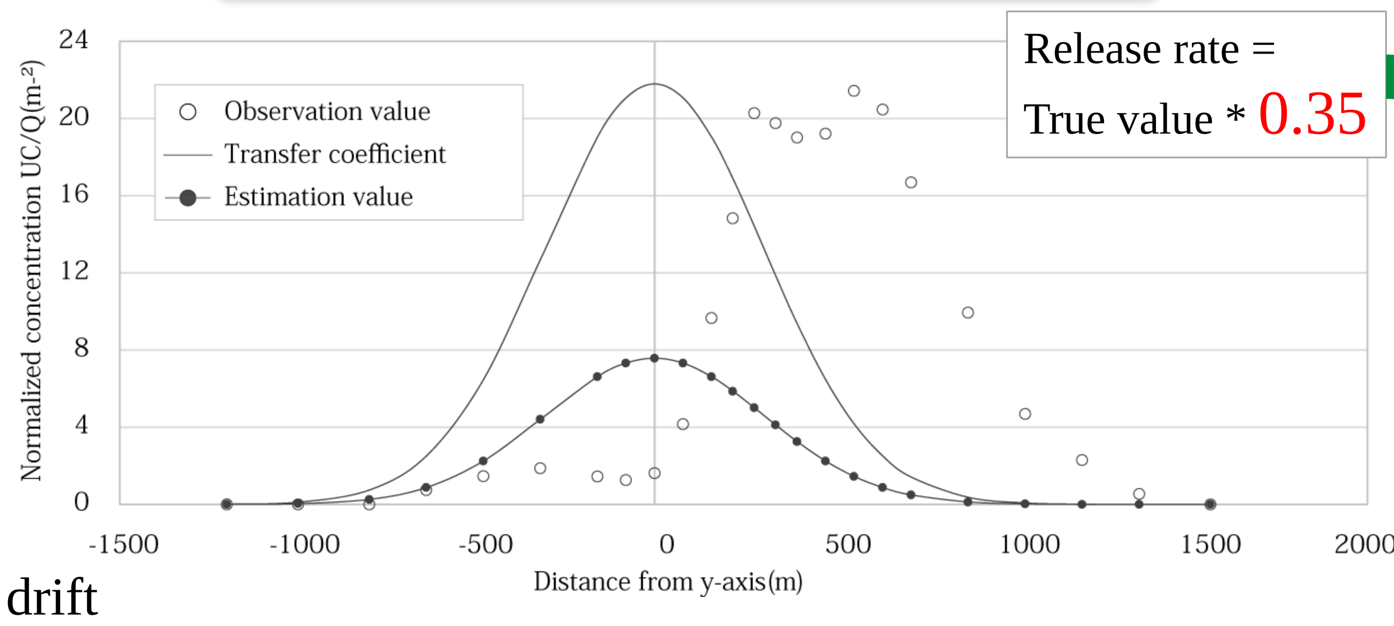


Fig. 3 Concentration distribution in complex terrain

Drift determined by wind tunnel experiments can be included through a simple adjustment to the Gaussian plume model, as below.

$$\frac{U\cdot C}{Q}=\frac{1}{2\pi\alpha_0\sigma_y\sigma_z}exp\left\{-\frac{(y-Y_d)^2}{2\sigma_y{}^2}\right\}exp\left\{-\frac{H_e{}^2}{2\sigma_z{}^2}\right\}$$

a) Without drift



b) With drift

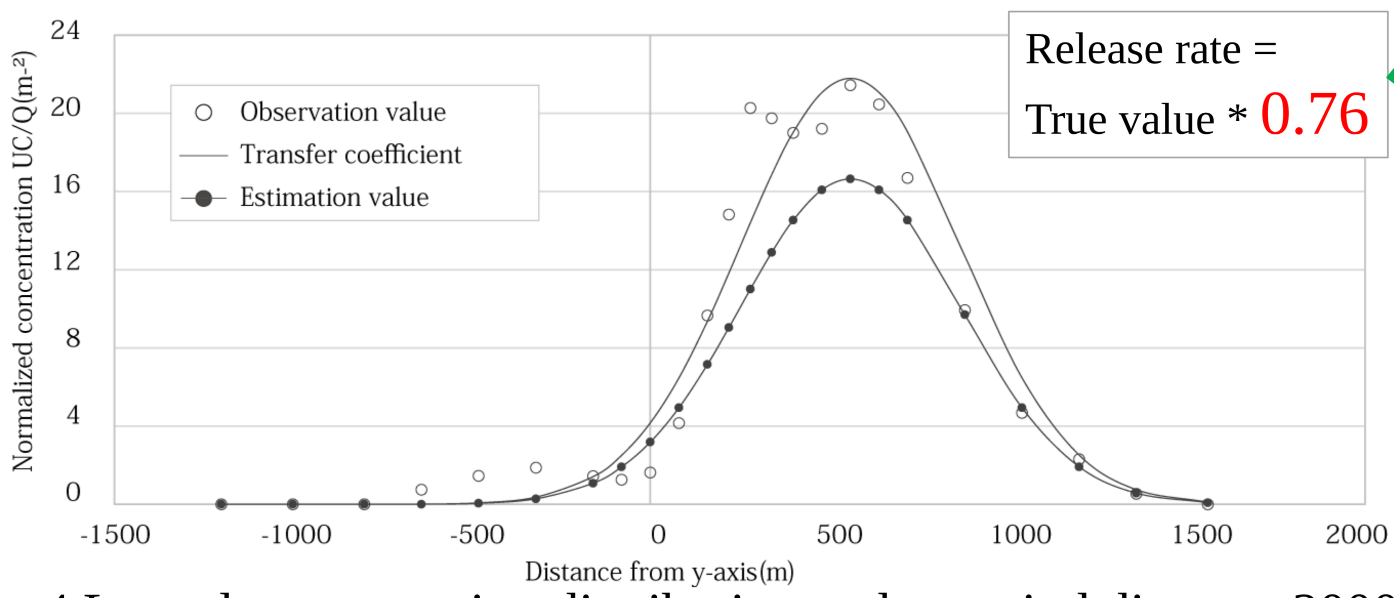


Fig. 4 Lateral concentration distribution at downwind distance 2000m

3. Uncertainty in atmospheric stability

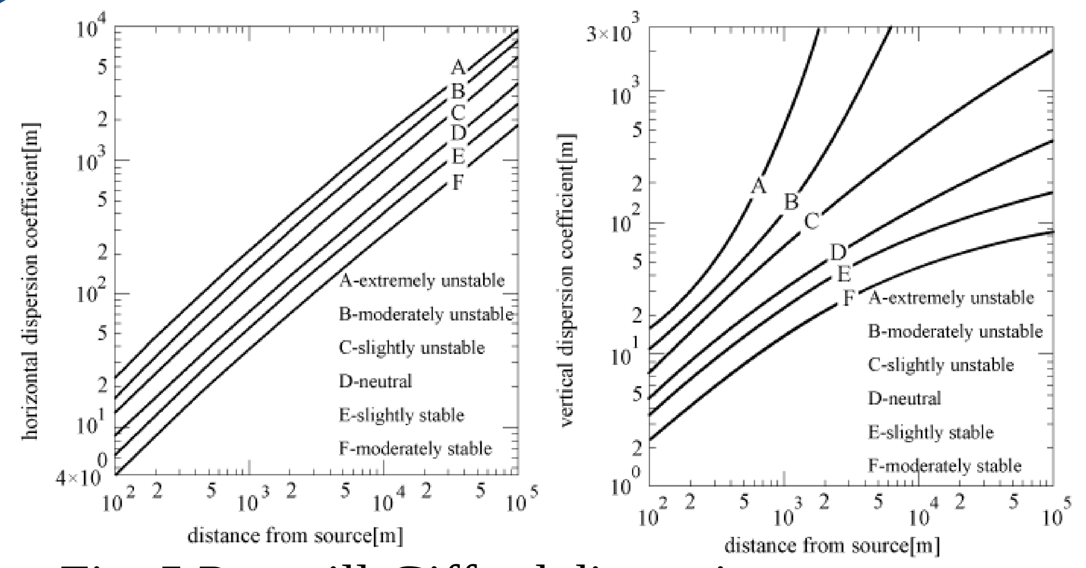


Fig. 5 Pasquill-Gifford dispersion curves

Calculation scheme:
(1) The effective source height (He) was determined from wind tunnel experiments of Mt. Tsukuba under neutral stability conditions.
(2) The concentration distribution was calculated by a Gaussian plume model, using the effective height (He) under several stabilities conditions. (Fig. 6)
(3) The release rate for each stability condition was estimated from the results calculated in (2).

Conclusion: The effect of atmospheric stability can be simulated by adjusting the dispersion coefficients in the Gaussian plume model.

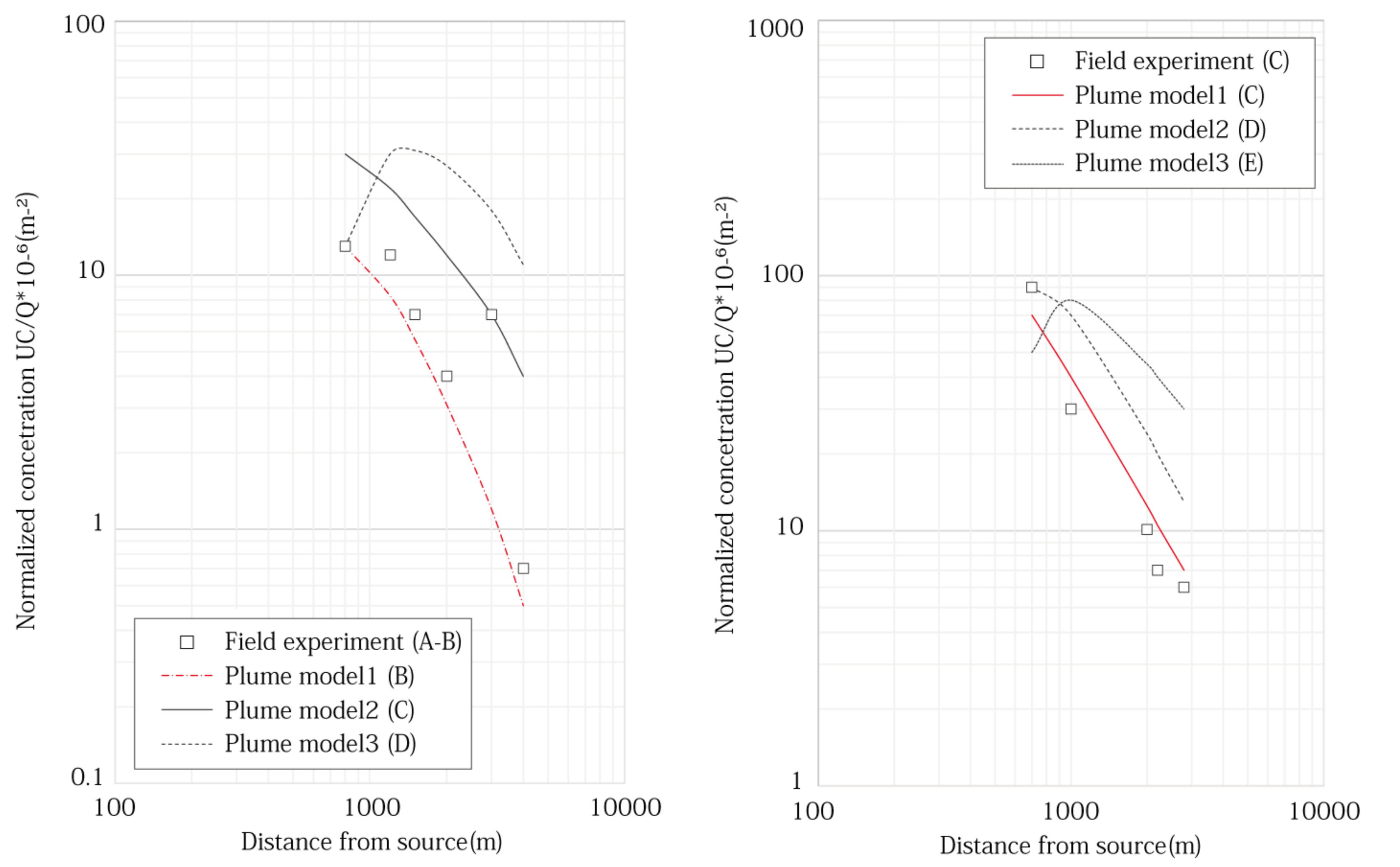


Fig. 6 Concentration distribution on plume axis at ground level

Release rate1 (B) = True value * 1.07
Release rate2 (C)= True value * 0.45
Release rate3 (D)= True value * 0.28

Release rate1 (C)= True value * 1.23
Release rate2 (D)= True value * 0.84
Release rate3 (E)= True value * 0.51

4. Uncertainty in emission release height

Effective release height is unknown in accidents such as that at Fukushima (e.g. explosion, leakage from building envelope …)

Concentration distribution depends on plume height near a source but becomes independent of release height far downwind.

Uncertainty can be reduced by only using data at large distances from a source.

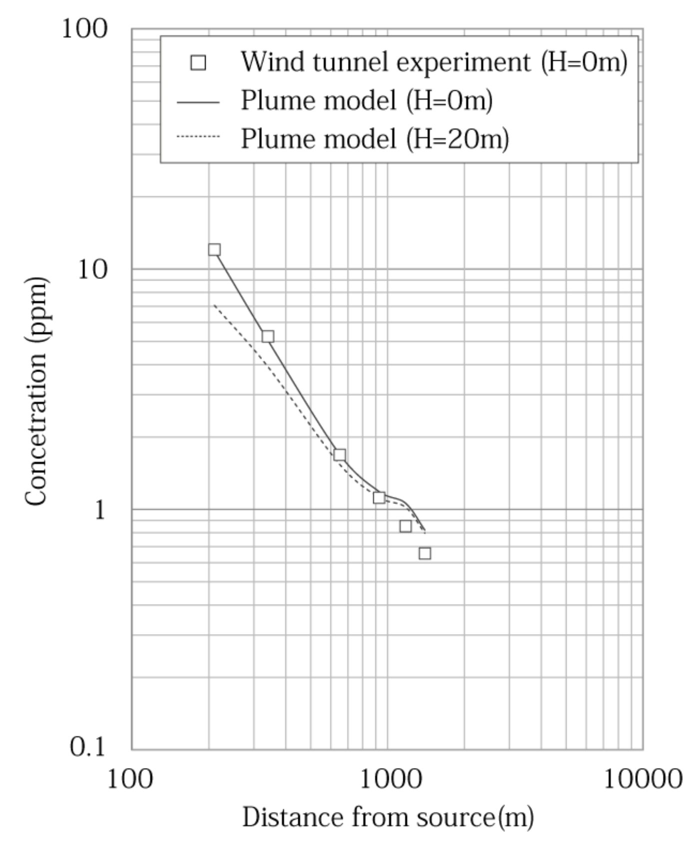


Fig. 8 Axial ground-level concentration

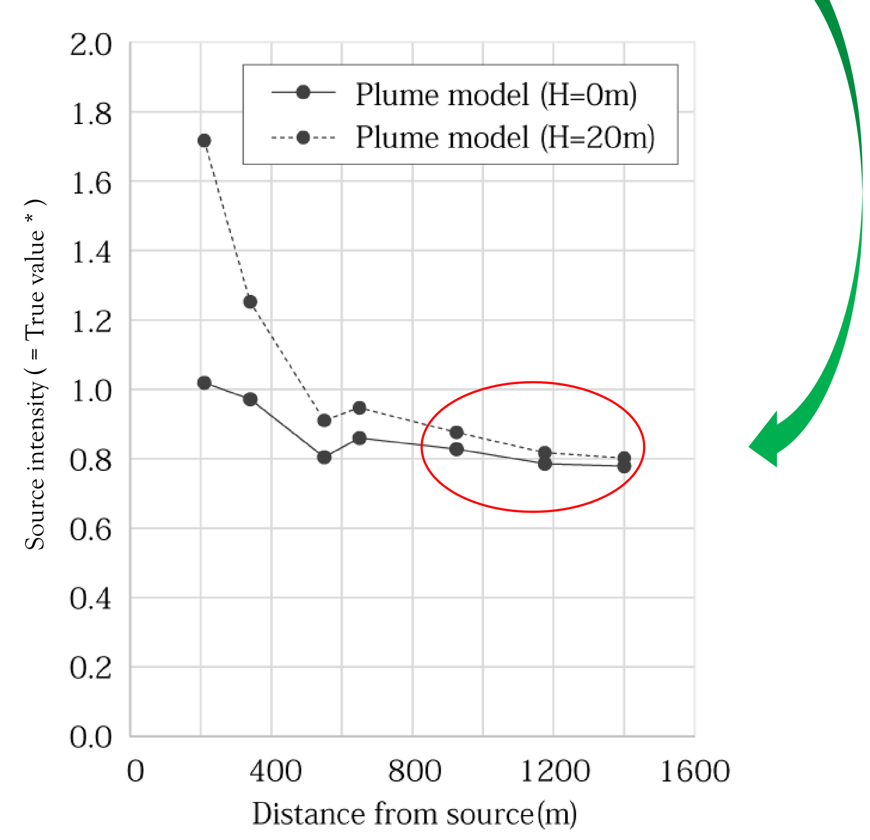


Fig. 9 Source intensity estimated from data at each downwind location

5. Conclusions

It was found that the following methods can reduce the uncertainty in source term estimation:
(1) Extend the average time of observations
(2) Use the drift specified by wind tunnel experiments in defining the Gaussian plume axis
(3) Fit the dispersion coefficients of the Gaussian plume model to field conditions
(4) Only use observations at large distances from the source