ADMS 4 Buildings Validation
Robins and Castro Wind Tunnel Experiments

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1 Introduction

Experiments were conducted in a simulated boundary layer representative of a suburban, or slightly rougher, environment in neutral stability conditions at a model scale of 1/300 of full scale. Concentrations were measured close to a cube-shaped building for emissions above the centre of the building roof. Release heights varying from one to two-and-a-half times the building height were considered for a range of emission velocities. The building was modelled perpendicular to the wind and at 45° to the wind.

Model runs for comparison with the experimental data have been carried out using ADMS 3.3 (version 3.3.1.0), ADMS 4.0 (version 4.0.2.0), and ISC-Prime (version 3). ISC-Prime contains the same buildings model that is in the AERMOD model which is why it is included here.

Section 2 describes the input data used for the model. The results are presented and discussed in Section 3.

2 Input data

2.1 Source parameters

Releases with a range of heights and emission velocities were considered. The range of source heights was such that $1 \leq Hs/Hb \leq 2.5$, where Hs is the source height and Hb is the building height. The range of emission velocities was $0.5 \leq Ws/Ue \leq 3.1$, where Ws is the emission velocity and Ue is the 'free-stream' wind speed, equal to 7.4 m/s.

The release was neutrally buoyant, hence the release temperature was set to ambient (15°C). In each case the source was situated directly above the centre of the building.

The source data are listed in **Table 1**.

Location	Height (m)	Exit V (m/s)	Exit T (°C)	Diameter (m)	Emission rate (g/s)
(0,0)	60, 75, 90, 120, 150	3.7, 22.94	15	3	1

Table 1 – Source input parameters. T is the temperature, V the velocity. The location is given relative to the building centre.

2.2 Meteorology

The input meteorology is listed in **Table 2**. In the wind tunnel, a 'free-stream' wind speed of 7.4 m/s was measured. This has been achieved in the model runs by setting the wind speed at

the top of the boundary layer (600 m full scale) to 7.4 m/s.

Wind speed (m/s)	7.4 at 600 m
Wind direction (°)	270
Boundary layer height (m)	600
1/Monin-Obukhov length (m^{-1}) (ADMS only)	0
Stability category (ISC-Prime only)	D
Site type (ISC-Prime only)	urban
Surface roughness (m) (ADMS only)	1.3

Table 2 − Meteorological data.

2.3 Buildings

The buildings data are given in **Table 3**. The building was modelled perpendicular to the wind and at 45° to the wind (see **Figure 1**).

Height (m)	Length (m)	Width (m)	Angle (°)
60	60	60	0, 45

Table 3 − Building dimensions.

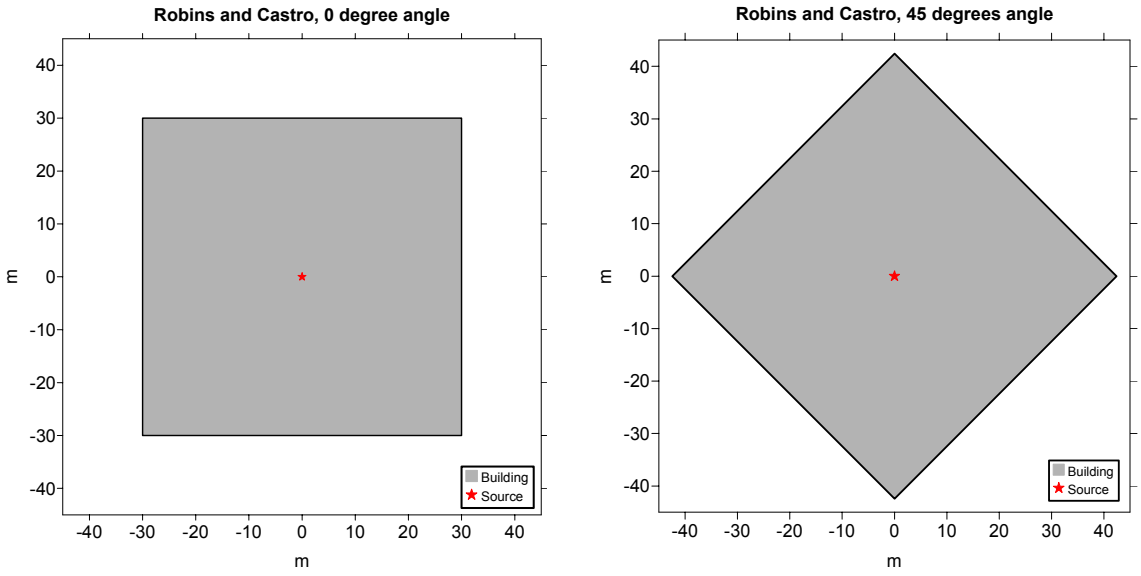

Figure 1 − Building modelled perpendicular to the wind (left) and at 45° to the wind (right).

3 Results

3.1 Output

Concentrations were calculated at a line of points downstream of the source to a distance of 10 building heights from the source. The maximum concentration and the distance downstream at which is occurred were recorded in each case. Non-dimensional concentrations *K* were then calculated as follows:

$$K = \frac{C\ Ue\ l^2}{Q}$$

where C is concentration (μg/m^3), Ue is the free-stream wind speed (m/s), l is the building height (m) and Q is the emission rate (μg/s).

The predicted maximum ground level concentrations have been compared with observed values. A statistical analysis of the results is presented in Section 3.2. Section 3.3 shows plots of the variation in maximum concentration with exit velocity and with building orientation.

3.2 BOOT statistics

The BOOT package produces statistics of the data that are useful in assessing model performance. Statistics calculated include mean, standard deviation (sigma), bias, normalised mean square error (NMSE), fraction of results where the modelled and observed concentrations agree to within a factor of two (fa2) and fractional bias (fb).

To avoid giving extra weight to the higher concentrations, observed and modelled concentrations were normalised by the observed value before the statistical analysis was performed. **Table 4** shows the results. From **Table 4** we see ADMS 4.0 out-performs the other models.

Data	Mean	Sigma	Bias	NMSE	Fa2	Fb	Cor[1]	AFb[2]
observed	1.00	0.00	0.00	0.00	1.000	0.000	1.000	0.000
ADMS 3.3	1.42	0.46	-0.42	0.27	0.850	-0.345	0.978	0.327
ADMS 4.0	0.96	0.32	0.04	0.11	0.850	0.036	0.841	0.290
ISC-Prime	1.33	0.75	-0.33	0.51	0.750	-0.285	0.563	0.402

Table 4 − Statistics of the data.

3.3 Graphical results

Results are presented as graphs showing the variation in magnitude and position of the observed and predicted maximum ground level concentration with source height. **Figures 2** to **5** show results with the building perpendicular to the wind direction ($\theta = 0°$). **Figures 6** to **9** show the results for the building at 45° to the wind direction ($\theta = 45°$). Results are presented for the minimum and maximum momentum emissions, $Ws/Ue = 0.5$ and 3.1, and for all models.

With the building perpendicular to the wind direction, all the models show some overprediction at lower stack heights. When the building is at 45° to the wind direction, ADMS 4.0, ISC and ISC-Prime tend to underpredict, whereas ADMS 3.3 overpredicts.

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[1] Correlation, not calculated by the BOOT package in this case, is defined as $\overline{\left(C_o - \overline{C_o}\right)\left(C_p - \overline{C_p}\right)} \Big/ \sigma_o \sigma_p$, where C_o and C_p are respectively observed and predicted concentration, and σ_o and σ_p are the standard deviations of the observed and predicted concentrations.

[2] Absolute fractional bias (AFb), not calculated by the BOOT package, is defined as $\frac{1}{n}\sum\left[\left|C_o - C_p\right| \Big/ 0.5\left(C_o + C_p\right)\right]$, where C_o and C_p are as above, and n is the number of observed/predicted concentrations.

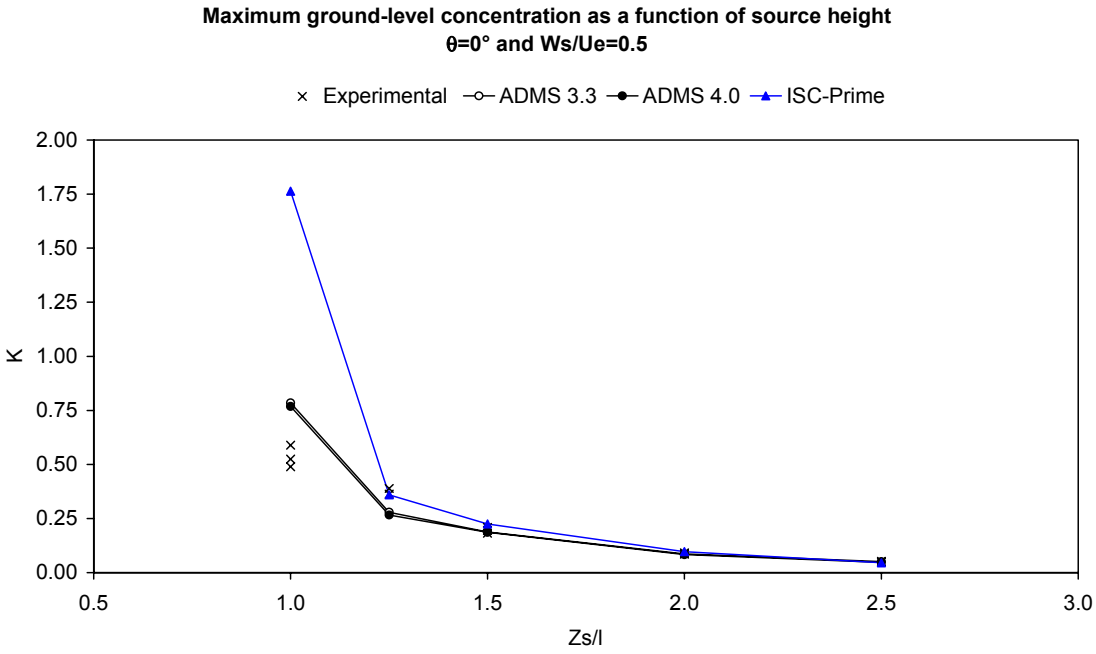

Figure 2 − Maximum ground-level concentration as a function of source height ($\theta = 0°$ and *Ws*/*Ue* = 0.5).

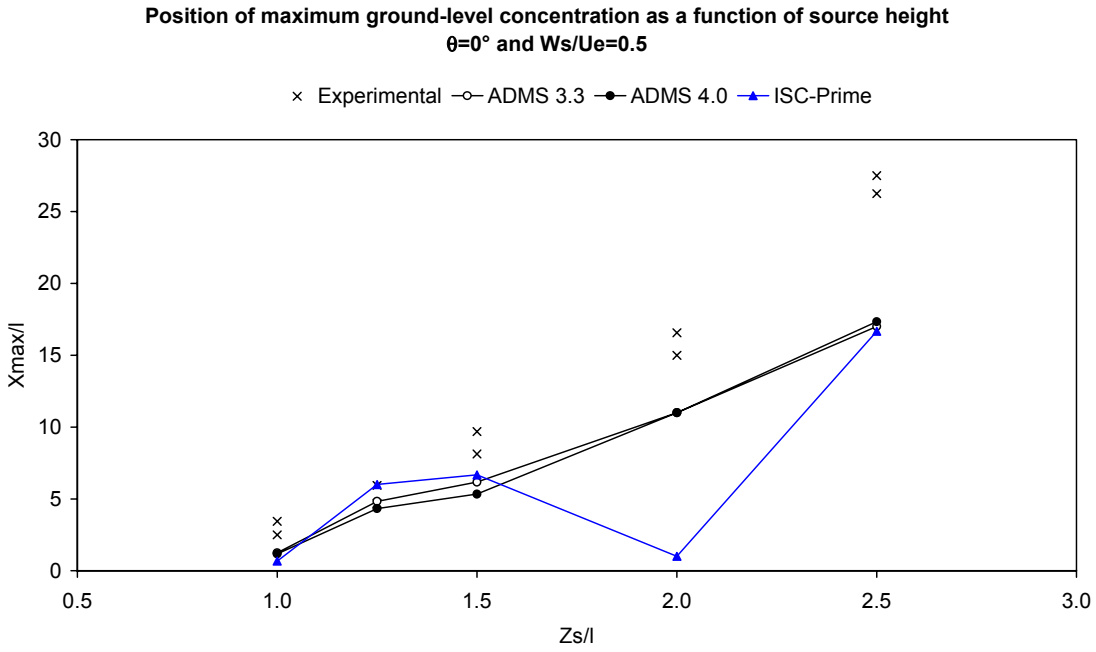

Figure 3 − Position of maximum ground-level concentration as a function of source height ($\theta = 0°$ and *Ws*/*Ue* = 0.5).

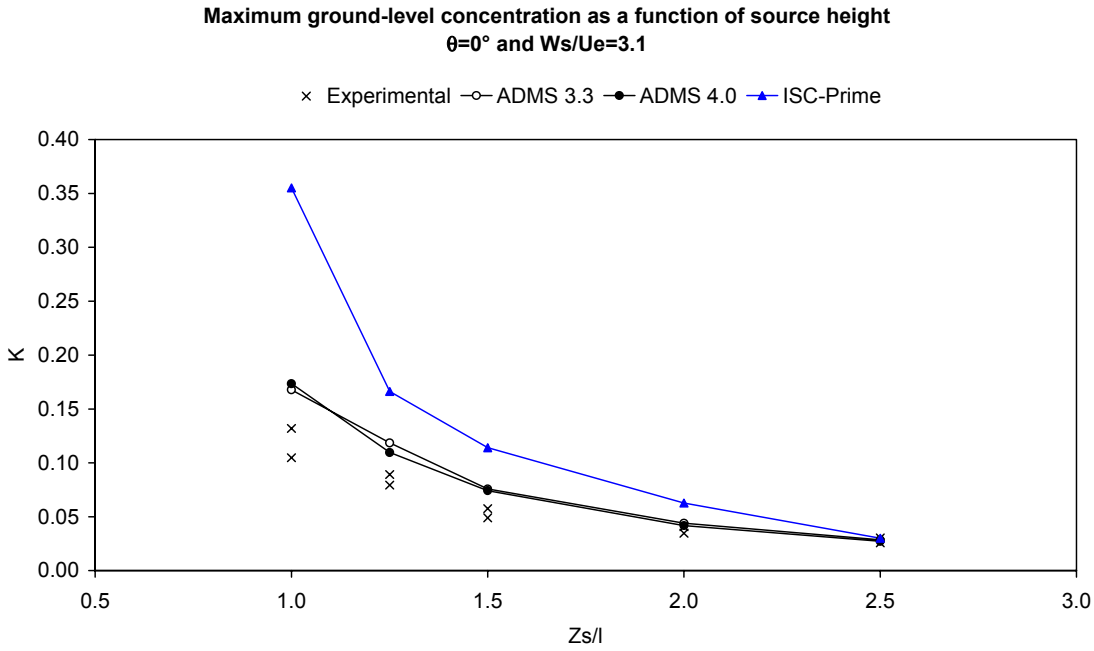

Figure 4 − Maximum ground-level concentration as a function of source height ($\theta = 0°$ and *Ws*/*Ue* = 3.1).

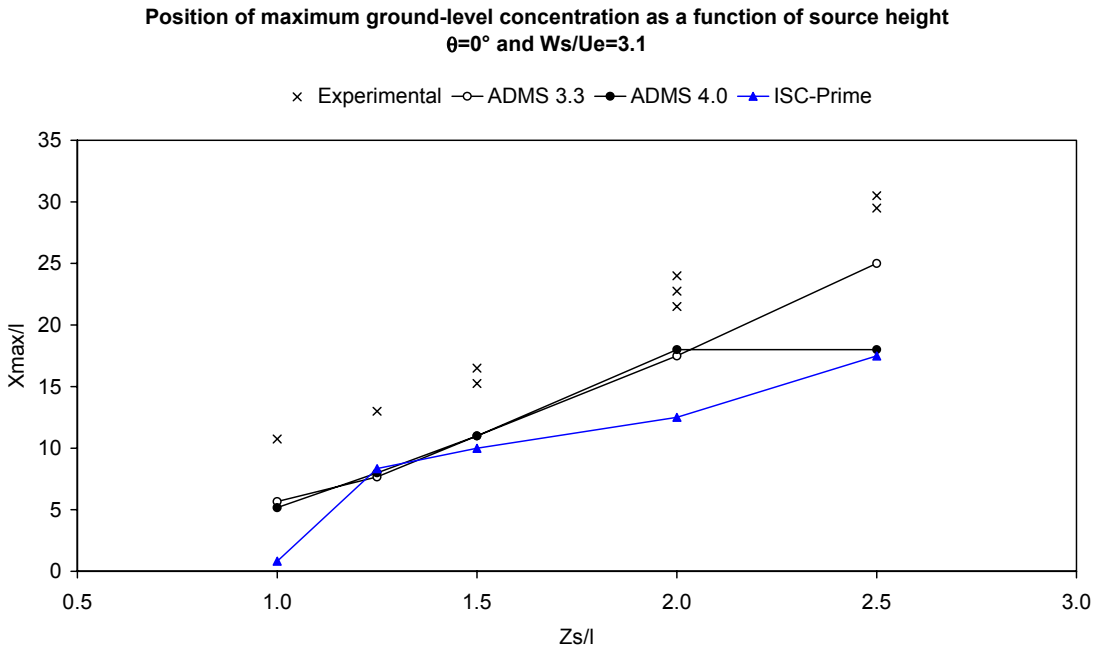

Figure 5 − Position of maximum ground-level concentration as a function of source height ($\theta = 0°$ and *Ws*/*Ue* = 3.1).

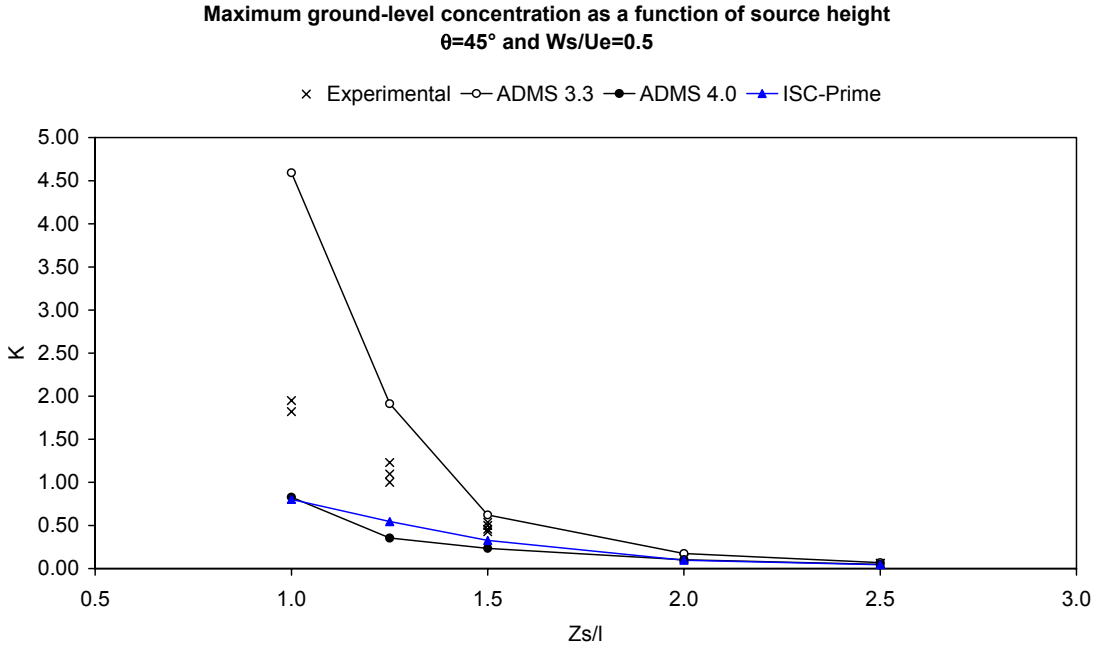

Figure 6 − Maximum ground-level concentration as a function of source height ($\theta = 45°$ and *Ws*/*Ue* = 0.5).

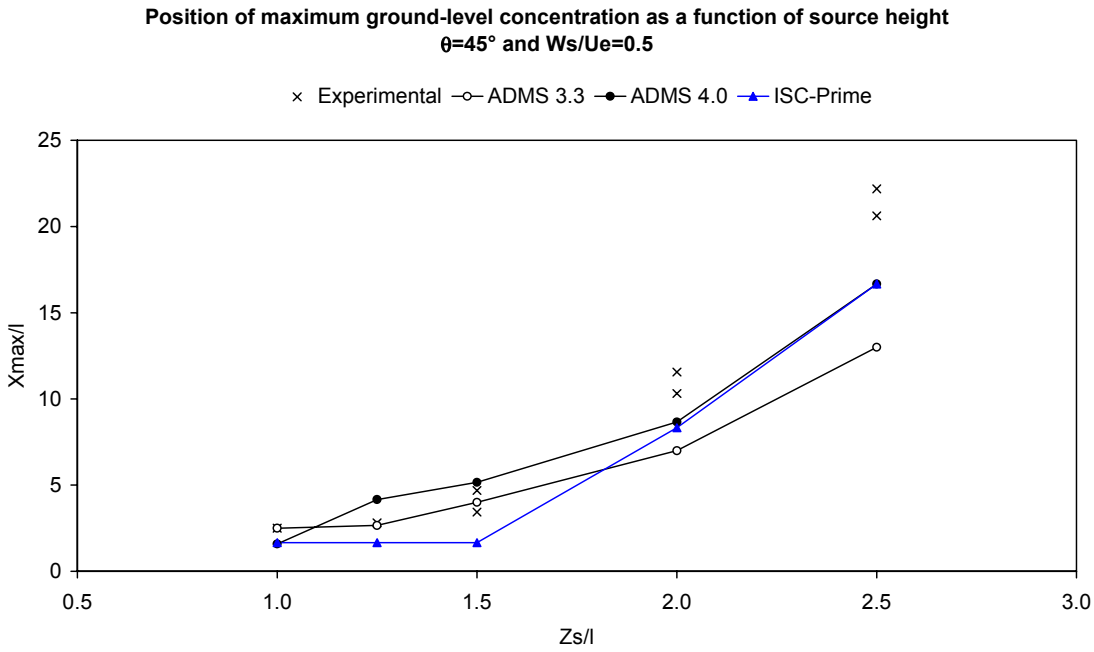

Figure 7 − Position of maximum ground-level concentration as a function of source height ($\theta = 45°$ and *Ws*/*Ue* = 0.5).

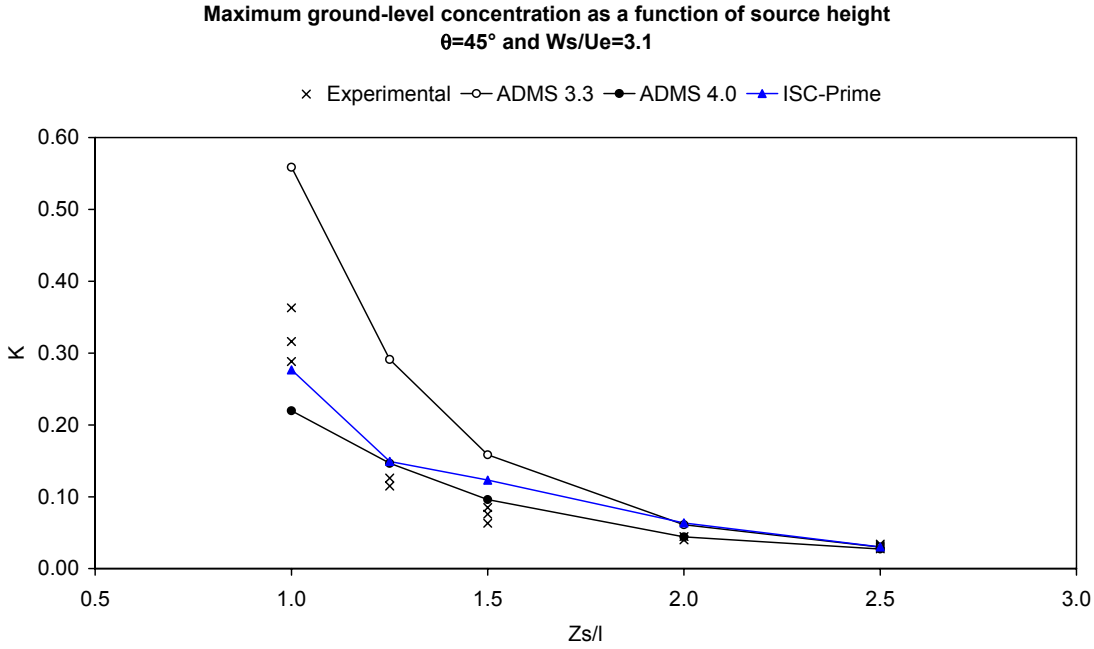

Figure 8 − Maximum ground-level concentration as a function of source height ($\theta = 45°$ and *Ws*/*Ue* = 3.1).

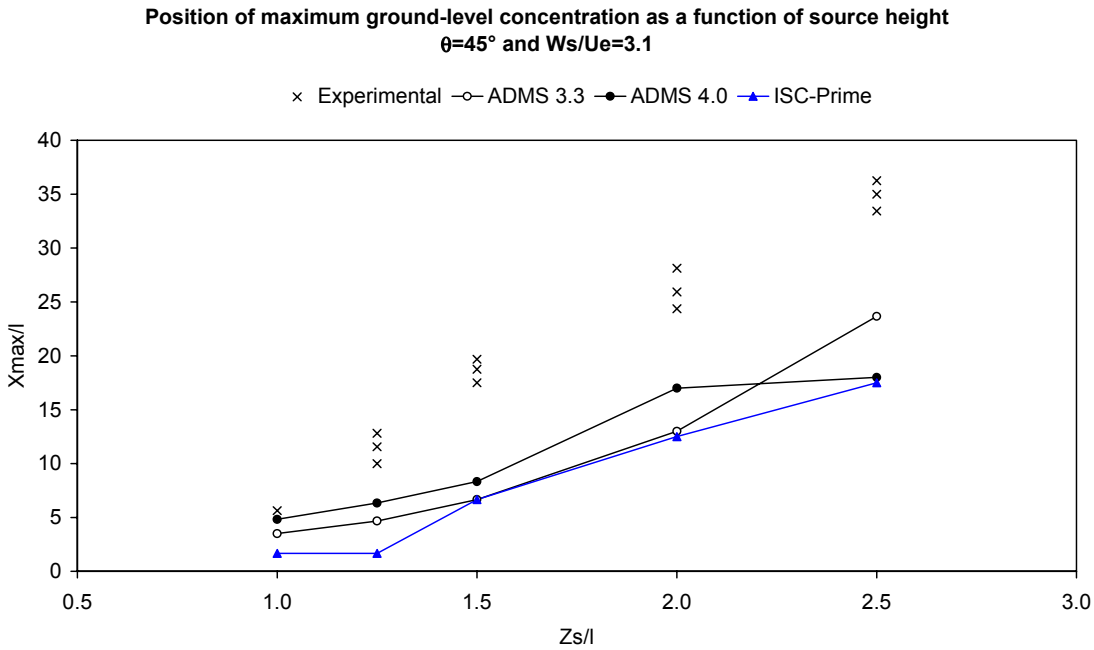

Figure 9 − Position of maximum ground-level concentration as a function of source height ($\theta = 45°$ and *Ws*/*Ue* = 3.1).