ADMS 6 Buildings Validation
Lee Power Plant Wind Tunnel Study

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Introduction

The Lee Power Plant wind tunnel study[1] [1] featured releases from steam boiler stacks with a common height of 64.8 m affected by a building tier with a height of 42.6 m. The world's largest fluid modelling study chamber at Monash University in Australia was used for these experiments (see plan view in **Figure 1**).

In neutral conditions, stack-top speeds (at the 64.8 m level) ranged in real-world equivalents from 5 to 40 m/s. There were 78 combinations of wind direction, wind speed, and plume buoyancy tested for the neutral cases.

Stable meteorological conditions were also simulated but data from these test cases are not used in this report.

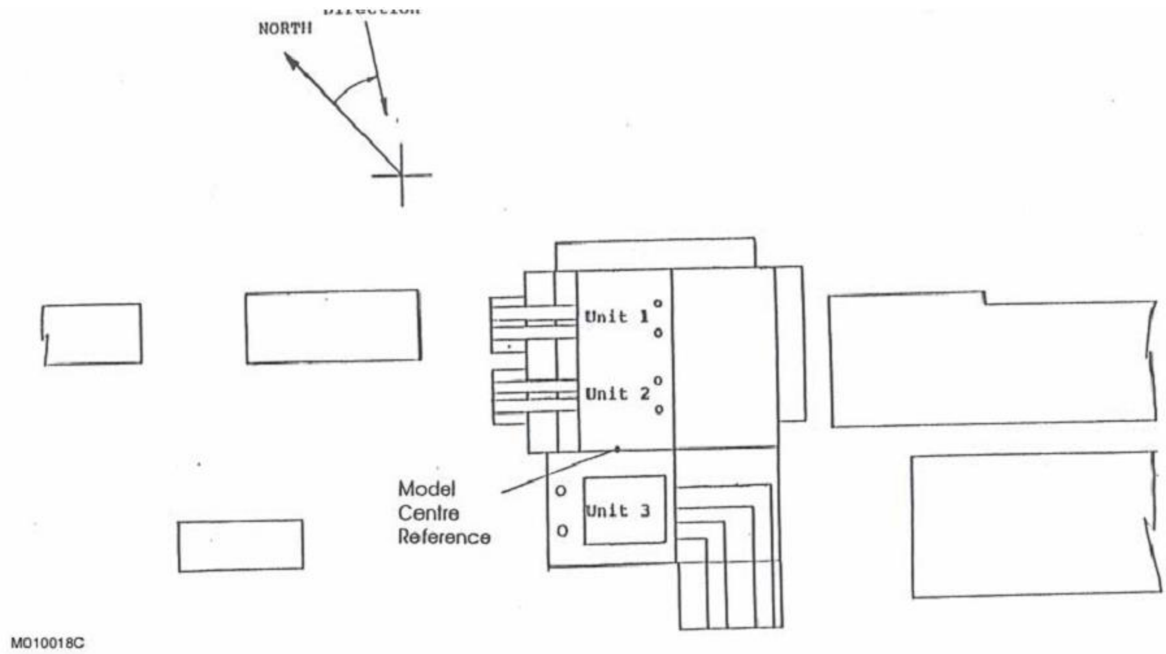

Figure 1 − Plan view of the Lee Power Plant model and nearby buildings showing the power station units and the zero reference position used in the Monash wind tunnel tests.

The tracer sampler coverage included ground-level concentrations at six distances ranging from the cavity zone to beyond the wake (150-900 m). The distances were 150, 300, 450, 600, 750

[1] Note that the study description and **Figure 1** have been taken directly from the document [1].

and 900 m.

The input data for the ADMS runs were taken from the AERMOD files downloaded from the United States Environmental Protection Agency website [2]. These data included the arcwise maximum observed concentrations that have been used for comparison with the ADMS modelled concentrations.

This document compares the results of ADMS 5.2.0.0 (hereafter referred to as ADMS 5.2) with those of ADMS 6.0.0.1 (hereafter referred to as ADMS 6.0).

Section 1 describes the input data used for the model. The results are presented in Section 2 and discussed in Section 3.

1 Input data

Study details are given in Sections 1.1 to 1.5 below.

1.1 Study area

The latitude of the site is 40°N and the surface roughness was taken to be 0.02 m.

1.2 Source parameters

The source parameters are summarised in **Table 1**. An emission rate of 1 g/s was used for all stacks (indicating that the observed concentrations supplied in [2] have been normalised by the emission rate) and three loading conditions (50, 75 and 100%) with different source release parameters were tested.

<table>
<tr><th>Source name</th><th>Location</th><th>h (m)</th><th>V (m/s)</th><th>T (°C)</th><th>D (m)</th><th>Note</th></tr>
<tr><td>1</td><td>(-1196.16, -940.028)</td><td rowspan="3">64.8</td><td rowspan="2">12.17</td><td rowspan="2">140</td><td rowspan="2">2.44</td><td rowspan="3">for 50% load</td></tr>
<tr><td>2</td><td>(-1210.81, -954.685)</td></tr>
<tr><td>3</td><td>(-1251.26, -955.005)</td><td>17.51</td><td>140</td><td>2.74</td></tr>
<tr><td>1</td><td>(-1196.16, -940.028)</td><td rowspan="3">64.8</td><td rowspan="2">17.21</td><td rowspan="2">169</td><td rowspan="2">2.44</td><td rowspan="3">for 75% load</td></tr>
<tr><td>2</td><td>(-1210.81, -954.685)</td></tr>
<tr><td>3</td><td>(-1251.26, -955.005)</td><td>26.21</td><td>151</td><td>2.74</td></tr>
<tr><td>1</td><td>(-1196.16, -940.028)</td><td rowspan="3">64.8</td><td rowspan="2">22.24</td><td rowspan="2">193</td><td rowspan="2">2.44</td><td rowspan="3">for 100% load</td></tr>
<tr><td>2</td><td>(-1210.81, -954.685)</td></tr>
<tr><td>3</td><td>(-1251.26, -955.005)</td><td>32.98</td><td>162</td><td>2.74</td></tr>
</table>

Table 1 − Source input parameters. h is the stack height, V the exit velocity, T the exit temperature, D the diameter.

1.3 Receptors

The receptor network consisted of radially spaced monitors. The receptors were located at distances of 150, 300, 450, 600, 750 and 900 m and were spaced at 10° intervals from 0 to 360° with (-1219.32, -949.9) as the origin. **Figure 2** shows the location of receptors.

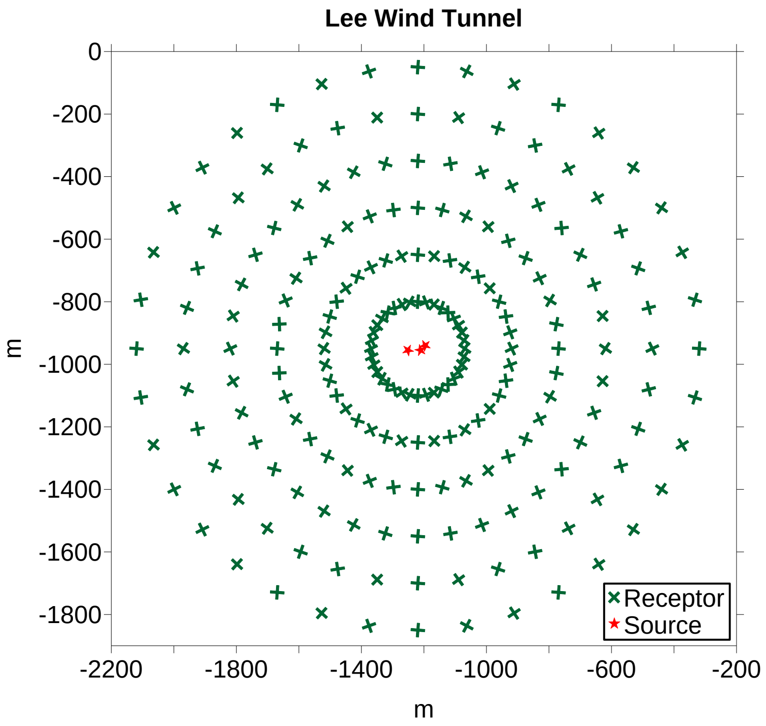

Figure 2 − The receptor network.

1.4 Meteorological data

The experiment consisted of 228 neutral met lines. The recorded wind profile included data at heights of 10 and 64.8 m. There were 6 wind speeds varying from 3.9 to 32.0 m/s (for the north-easterly wind direction) and 3.7 to 31.9 m/s (for the south-westerly wind direction). There were 7 wind directions varying between 345 and 105° (for the north-easterly wind direction) and between 165 and 285° (for the south-westerly wind direction). The ambient temperature for all neutral experiments was 19.9°C.

1.5 Buildings

The building dimensions are given in **Table 2**. The building locations relative to the modelled stacks are shown in **Figure 3** (a local coordinate system has been used at the site). The ADMS model set up included only buildings that were above one-third the height of the source height, resulting in two buildings being modelled (data for additional buildings were available).

Building name	Length (m)	Width (m)	Height (m)
Build1	48.8	25.3	42.6
Build2	34.7	31.1	41.3

Table 2 – Building dimensions.

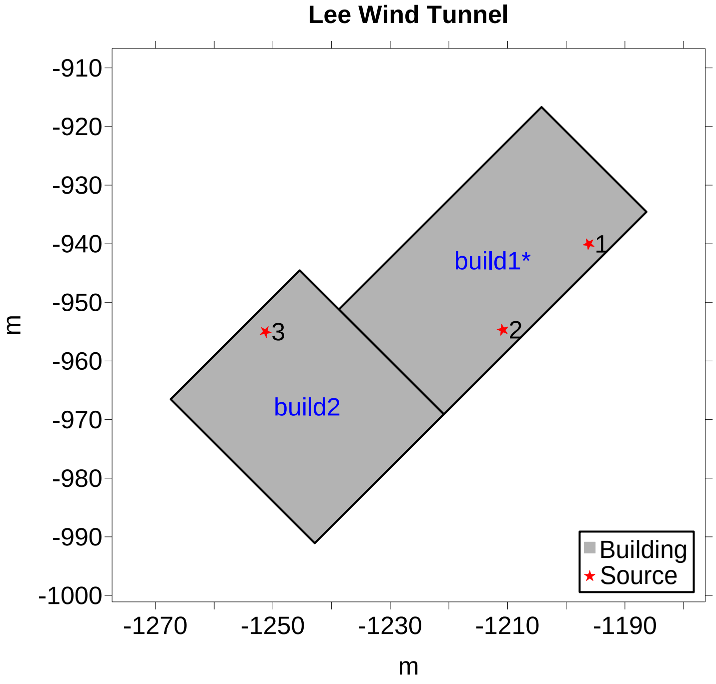

Figure 3 − The building and stack locations.

2 Results

For this experiment, arc maximum modelled and observed concentration values are compared.

Scatter plots and quantile-quantile plots of model results against observed data are presented in Section 2.1. Other statistical analysis of the data is presented in Section 2.2. The graphs and statistical analysis have been produced by the Model Evaluation Toolkit v5.2.

2.1 Scatter and quantile-quantile plots

Figure 4 shows scatter plots and **Figure 5** shows quantile-quantile plots of the results. Note that these quantile-quantile plots are linear; care should be exercised when comparing these plots with similar ones presented with logarithmic axes.

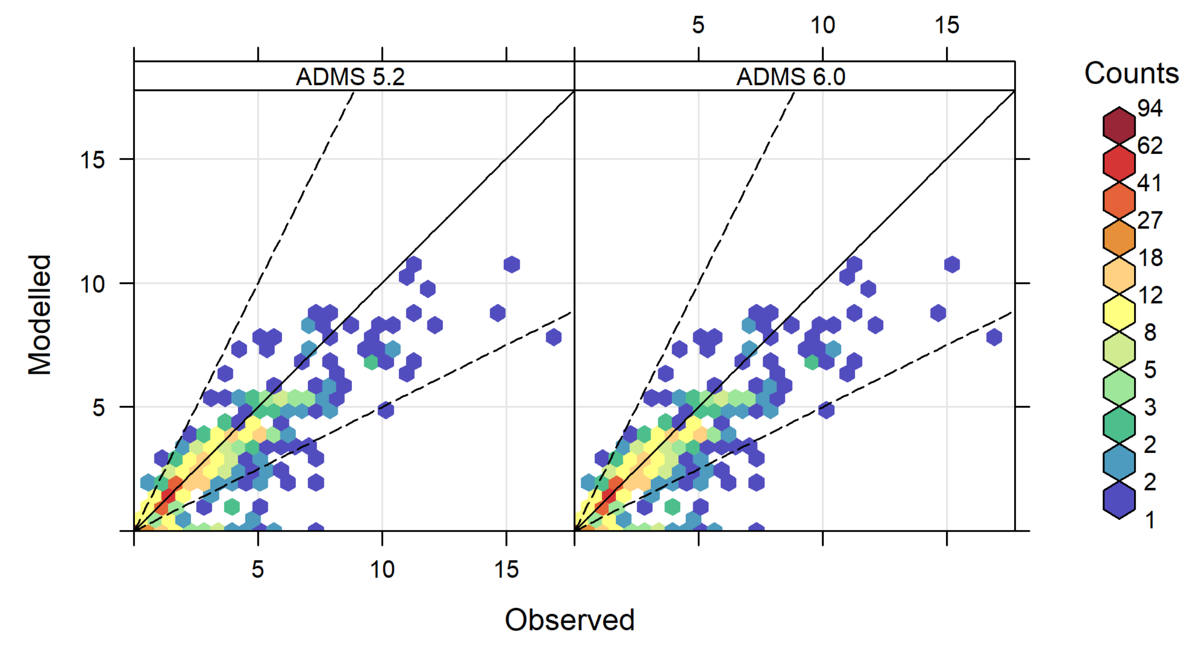

Figure 4 − Scatter plots of ADMS results against observed data for neutral conditions (us/m^3).

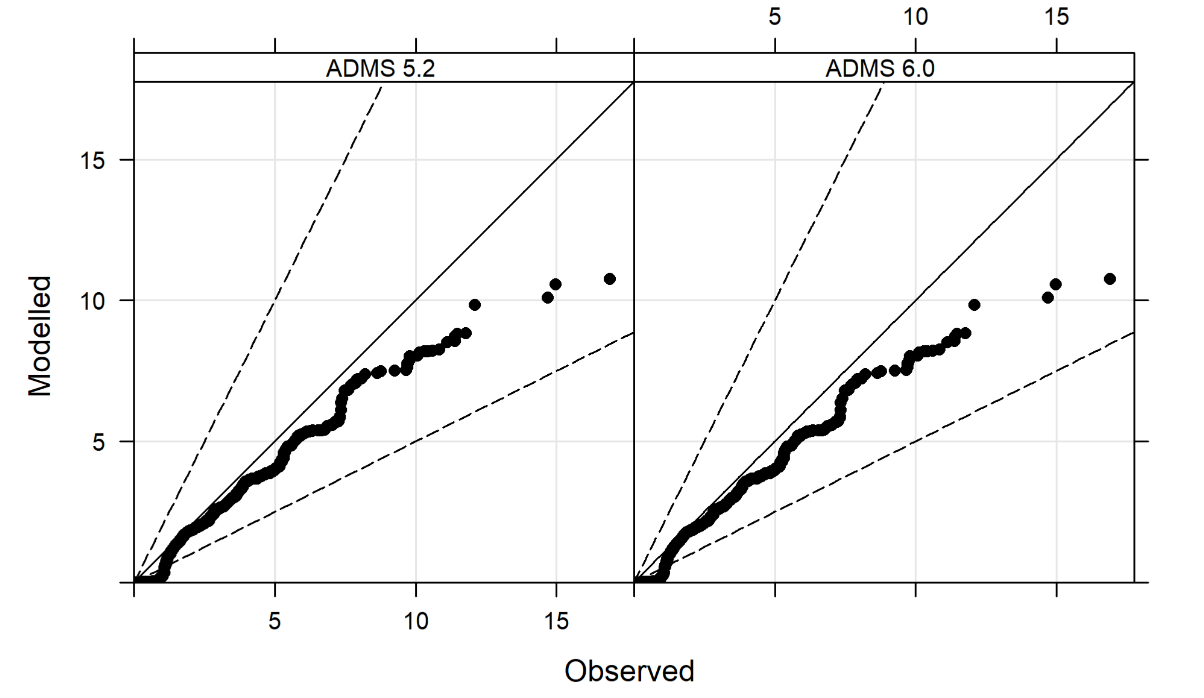

Figure 5 − Quantile-quantile plots of ADMS results against observed data for neutral conditions (us/m^3).

2.2 Statistics

The Model Evaluation Toolkit 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), correlation (Cor), fraction of results where the modelled and observed concentrations agree to within a factor of two (Fa2), fractional bias (Fb) and fractional standard deviation (Fs). **Table 3** shows statistical results for all runs, for neutral conditions.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
Observed	2.77	2.53	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 5.2	2.25	2.11	-0.52	0.30	0.867	0.770	-0.206	-0.183
ADMS 6.0	2.25	2.11	-0.52	0.30	0.867	0.770	-0.206	-0.183

Table 3 – Model evaluation statistics for neutral conditions.

3 Discussion

The model has a tendency to predict slightly lower concentrations than those observed, though the correlation is still good (0.87).

There are no significant differences between ADMS 5.2 and ADMS 6.0. The ADMS 6.0 buildings code developments relating to how plumes that directly impact a building are modelled as well as how the ground-level plume downwind of the recirculation region is modelled are unlikely to have a large effect in this study due to the relative height of the sources compared with the buildings.

4 References

[1] United States Environmental Protection Agency, 2003: *AERMOD, Latest Features and Evaluation Results*. EPA-454/R-03-003.

[2] United States Environmental Protection Agency website, *Model Evaluation Databases*. https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

[3] Stidworthy A, Carruthers D, Stocker J, Balis D, Katragkou E, and Kukkonen J, 2013: *MyAir Toolkit for Model Evaluation*. 15th International Conference on Harmonisation, Madrid, Spain, May 2013.

[4] Thunis P., E. Georgieva, S. Galmarini, 2010: *A procedure for air quality models benchmarking*. https://fairmode.jrc.ec.europa.eu/document/fairmode/WG1/WG2_SG4_benchmarking_V2.pdf

[5] David Carslaw and Karl Ropkins (2011). *openair: Open-source tools for the analysis of air pollution data*. R package version 0.4-7. http://www.openair-project.org/

[6] Chang, J. and Hanna, S, 2004: *Air quality model performance evaluation*. Meteorol. Atmos. Phys. **87**, 167-196.