ADMS 5 Buildings Validation
Lee Power Plant Wind Tunnel Study

Cambridge Environmental Research Consultants
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1 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**).

Stable meteorological conditions were simulated by using an inverted model of the facility, which was suspended from the ceiling of the tunnel. A stably stratified layer was developed along the tunnel by heating the inflowing air, and a buoyant plume was simulated by using a negatively buoyant gas mixture. A stable potential temperature lapse rate of 0.035 deK/m was modeled with a stack-top real-world equivalent wind speed of 7 m/s, with several wind directions being tested.

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.

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.

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

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 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 5.1.2.0 (hereafter referred to as ADMS 5.1).

Section 2 describes the input data used for the model. The results are presented in Section 3 and discussed in Section 4.

2 Input data

Study details are given in Sections 2.1 to 2.5 below.

2.1 Study area

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

2.2 Source parameters

The source parameters are summarised in **Table 1**, with an emission rate of 1 g/s 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%) and using the "other" pollutant.

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

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

2.3 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.

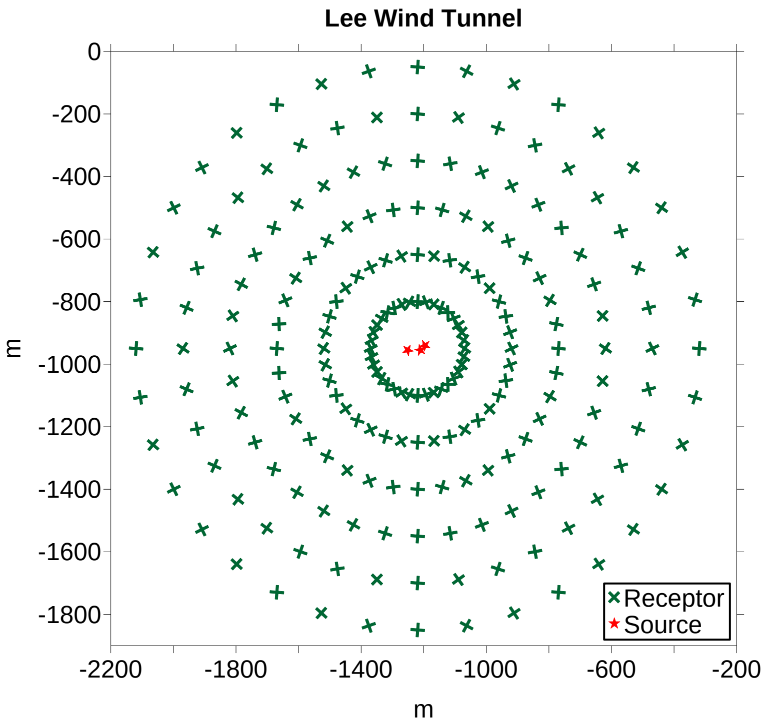

Figure 2 – The receptor network.

2.4 Meteorological data

The experiment consisted of 228 neutral. The recorded wind profile included data at heights of 10 and 64.8 m.

For *neutral* conditions and constant wind direction experiments, 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). For neutral conditions and constant wind speed experiments, 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.

2.5 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.

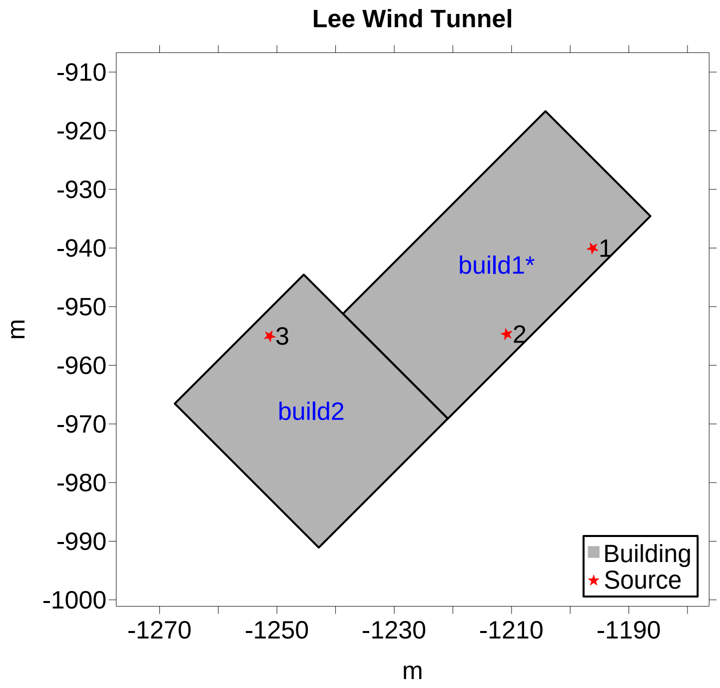

Figure 3 – The building and stack locations.

3 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 3.1. Other statistical analysis of the data is presented in Section 3.2. The graphs and statistical analysis have been produced by the MyAir Toolkit for Model Evaluation.

3.1 Scatter and quantile-quantile plots

Figure 4 shows the scatter plots of results for neutral conditions.

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

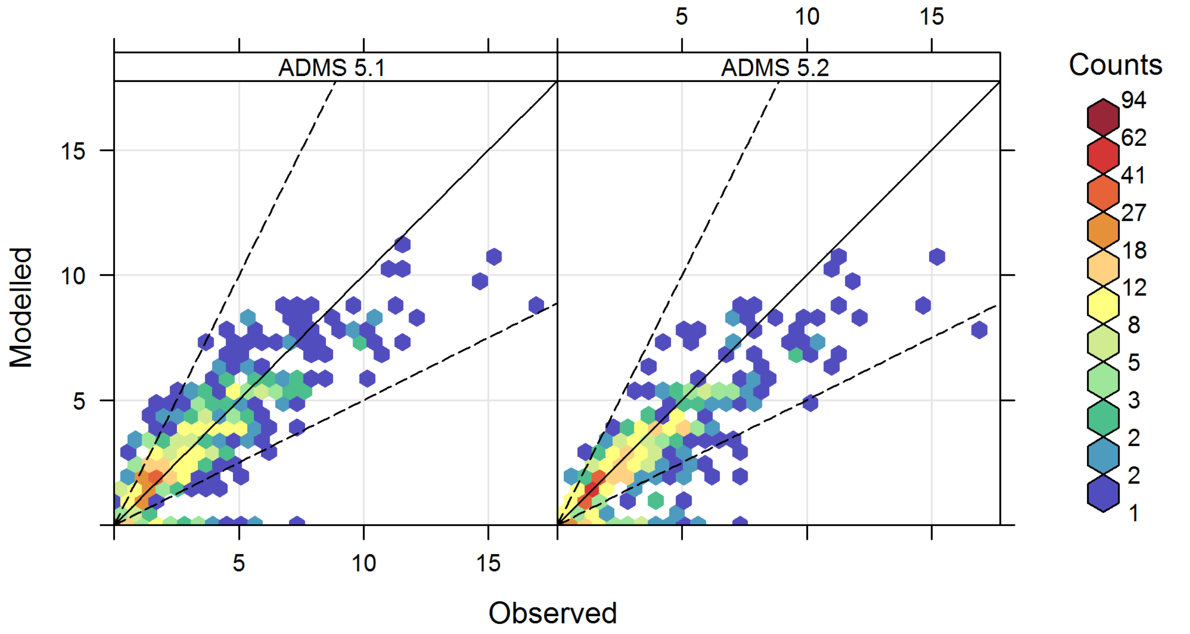

Figure 4 – Scatter plots of ADMS results against observed data for neutral conditions (us/m^3).

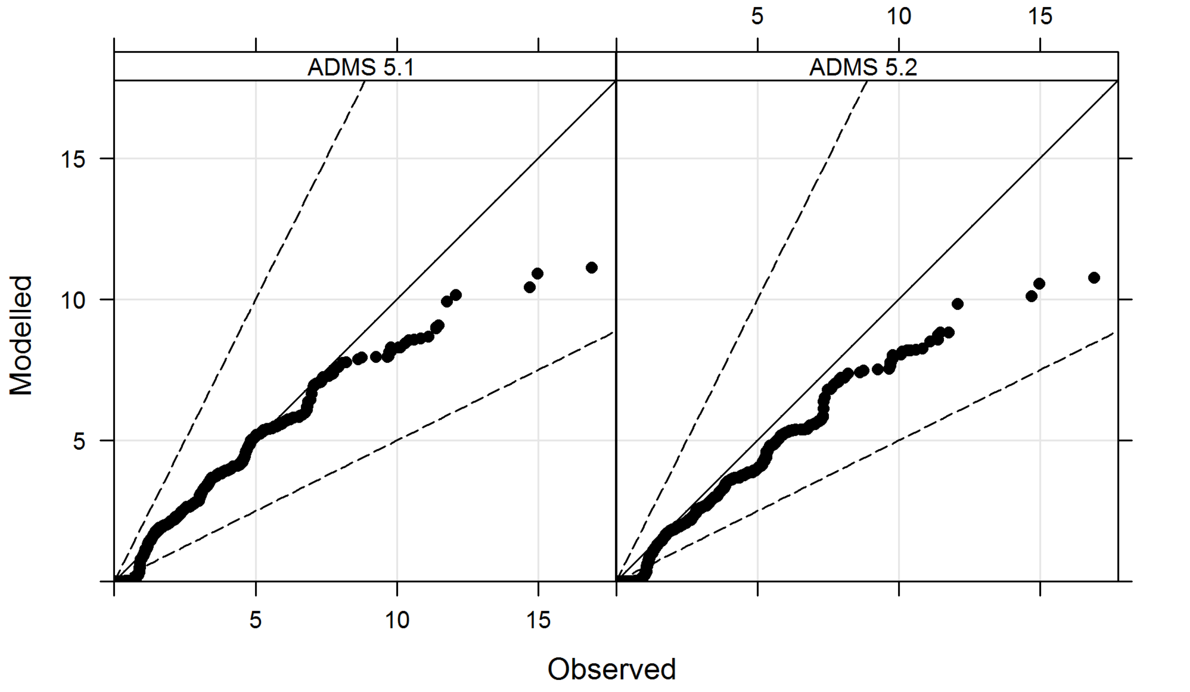

Figure 5 – Quantile-quantile plots of ADMS results against observed data for neutral conditions (us/m^3).

3.2 Statistics

The MyAir 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). Note that the sign of the bias and fractional bias calculated by the Myair Toolkit is consistent with openair [5] and the DELTA tool [4], but not with the BOOT package [6]. **Tables 3** and Error! Reference source not found. show 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 5.1	2.65	2.26	-0.11	0.23	0.861	0.789	-0.042	-0.112
ADMS 5.2	2.25	2.11	-0.52	0.30	0.867	0.770	-0.206	-0.183

Table 3 – Model evaluation statistics for neutral conditions.

4 Discussion

The differences between the concentrations predicted by ADMS 5.1 and ADMS 5.2 are relatively small. ADMS 5.2 predicts the neutral observed concentrations very well, with the correlation value being particularly good (0.87). The scatter plots show an improvement in the model representation of low to moderate concentrations, with a greater density of points lying on or close to the 1:1 line.

The ADMS 5 buildings module has been made more consistent between different building effects regions for ADMS 5.2, which may increase or decrease concentrations for some cases depending on the source, building and output point locations and characteristics. In addition the effects of building wake turbulence on plumes outside the wake have been improved.

5 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*. http://www.epa.gov/scram001/dispersion_prefrec.htm

[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*. http://fairmode.ew.eea.europa.eu/fol568175/work-groups

[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.