ADMS 4 Buildings Validation
Lee Power Plant Wind Tunnel Study

Cambridge Environmental Research Consultants
December 2010

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, and 14 combinations for the stable cases.

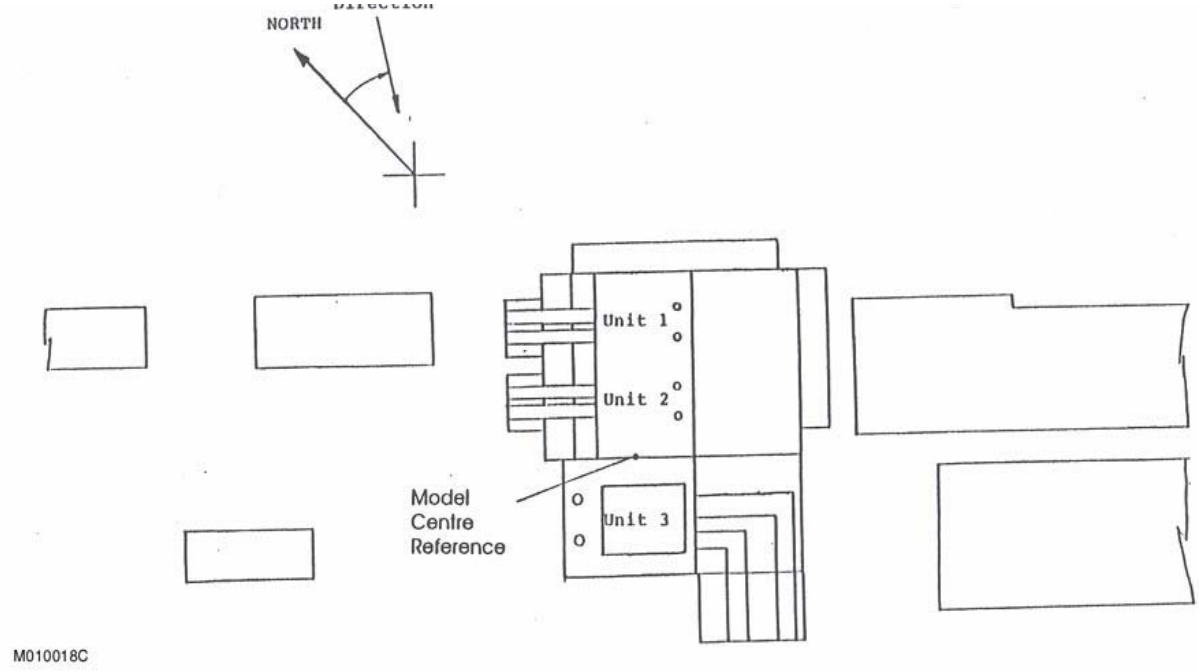

Figure 1 − Plan view of the Lee Power Plant model and nearby buildings showing the power station units and the zero reference position used in the Monash wind tunnel tests.

[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 4.1.0.0 (hereafter referred to as ADMS 4.1) with those of ADMS 4.2.2.0 (hereafter referred to as ADMS 4.2).

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

The data are grouped into neutral and stable conditions. 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. Each source is modelled separately for experimental conditions.

Source name	Location	h (m)	V (m/s)	T (°C)	D (m)	Note
1	(-1196.16, -940.028)	64.8	12.17	139.85	2.44	for 50% load
2	(-1210.81, -954.685)					
3	(-1251.26, -955.005)		17.51	138.85	2.74	
1	(-1196.16, -940.028)	64.8	17.21	168.85	2.44	for 75% load
2	(-1210.81, -954.685)					
3	(-1251.26, -955.005)		26.21	150.85	2.74	
1	(-1196.16, -940.028)	64.8	22.24	192.85	2.44	for 100% load
2	(-1210.81, -954.685)					
3	(-1251.26, -955.005)		32.98	161.85	2.74	

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

2.3 Receptors

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

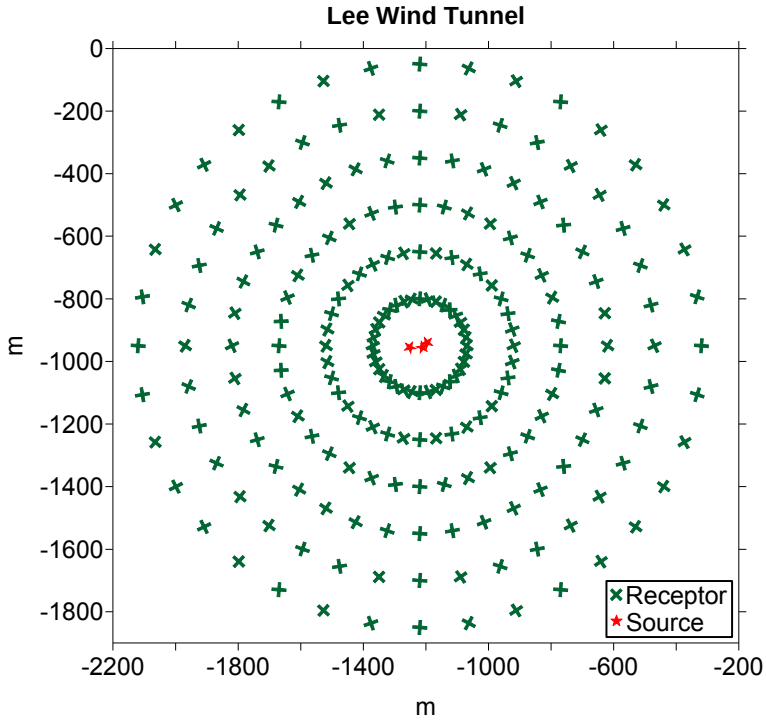

Figure 2 − The receptor network.

2.4 Meteorological data

The experiment consisted of 228 neutral and 14 stable conditions. The recorded wind profile used was at height 10 m 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.

For *stable* conditions and constant wind speed experiments, there were 7 wind directions varying between 345 and 105° (north-easterly) and between 165 and 285° (south-westerly). The ambient temperature for all stable experiments was 24.9°C.

Note on inconsistent source data

In the AERMOD meteorology source data (*.sfc*) files [2], for the stable case, the sensible heat flux is given as 0.1 W/m^2. However, for stable conditions the sensible heat flux should be negative. Therefore, when these conditions have been modelled in ADMS, the sensible heat flux has been taken as -0.1 W/m^2, as it has been assumed that the AERMOD definition has in some way taken into account that fact that the stable experiments were conducted in an inverted facility. Further, it is important to note that whilst the conditions in the wind tunnel have been set up to represent stable conditions, the meteorological conditions were described as neutral by the ADMS meteorological pre-processor.

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	48.84	25.30	42.55008
Build2	34.72	31.10	41.3004

Table 2 – Building dimensions.

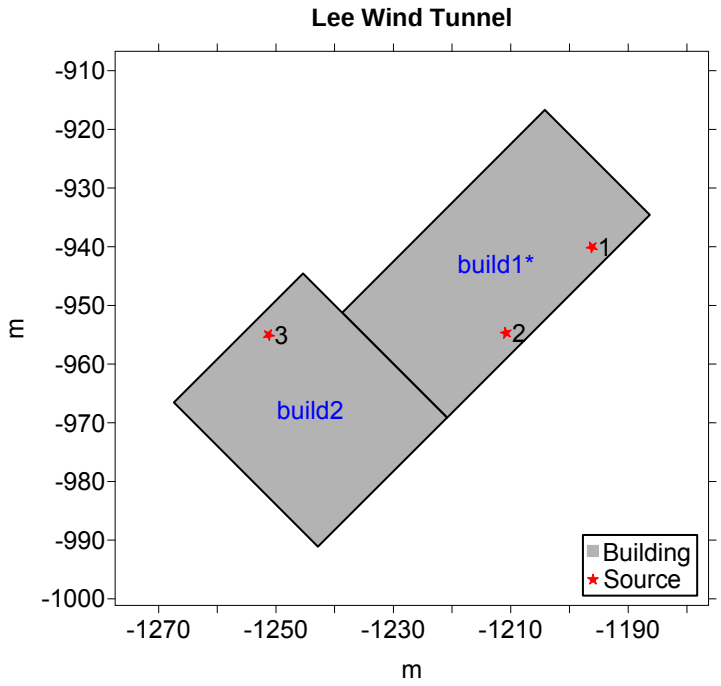

Figure 3 − The building and stack locations.

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. The data were also processed using the BOOT statistical package; these results are given in Section 3.2.

3.1 Scatter and quantile-quantile plots

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

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

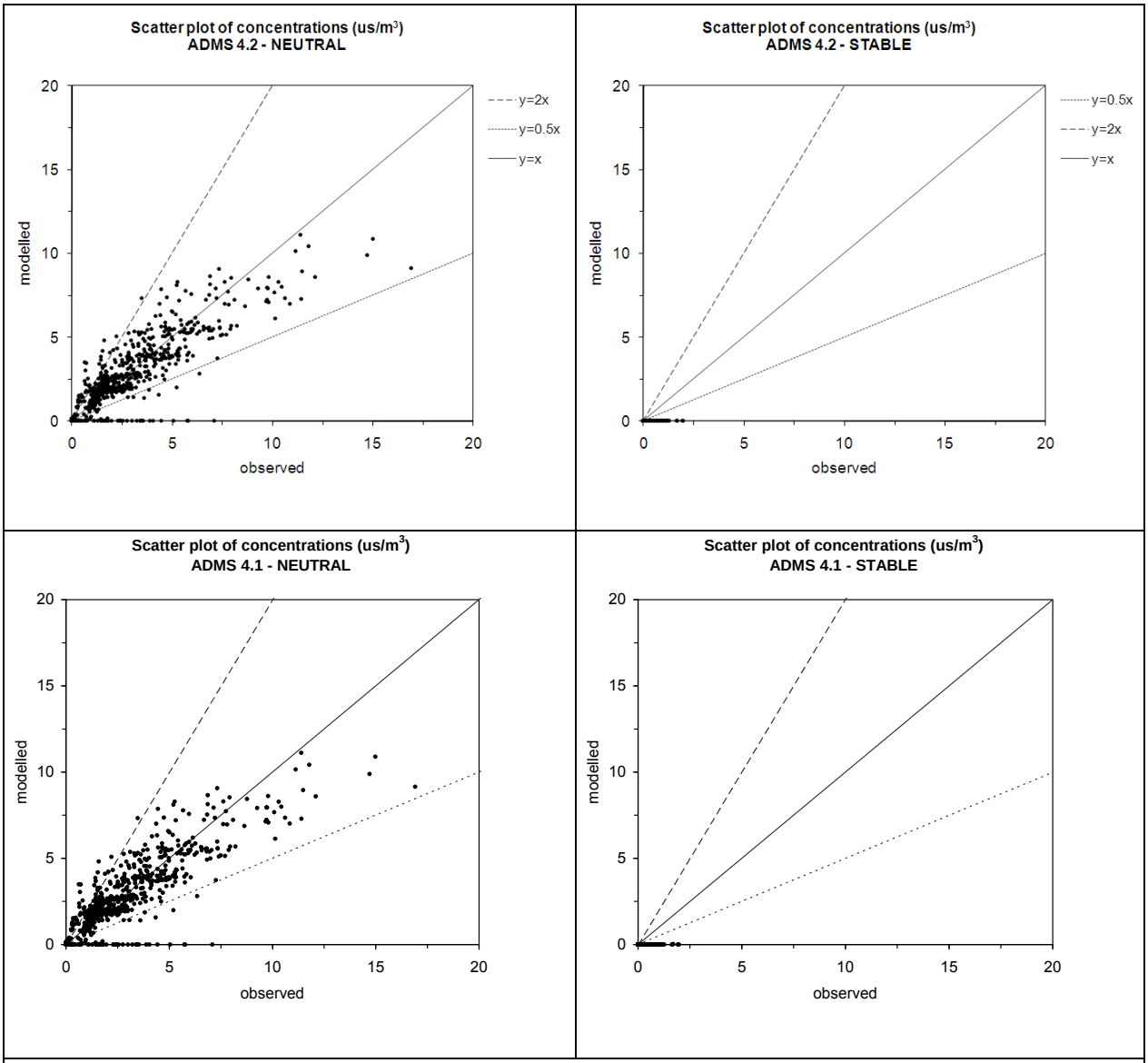

Figure 4 − Scatter plot of ADMS results against observed data for neutral and stable conditions (us/m^3).

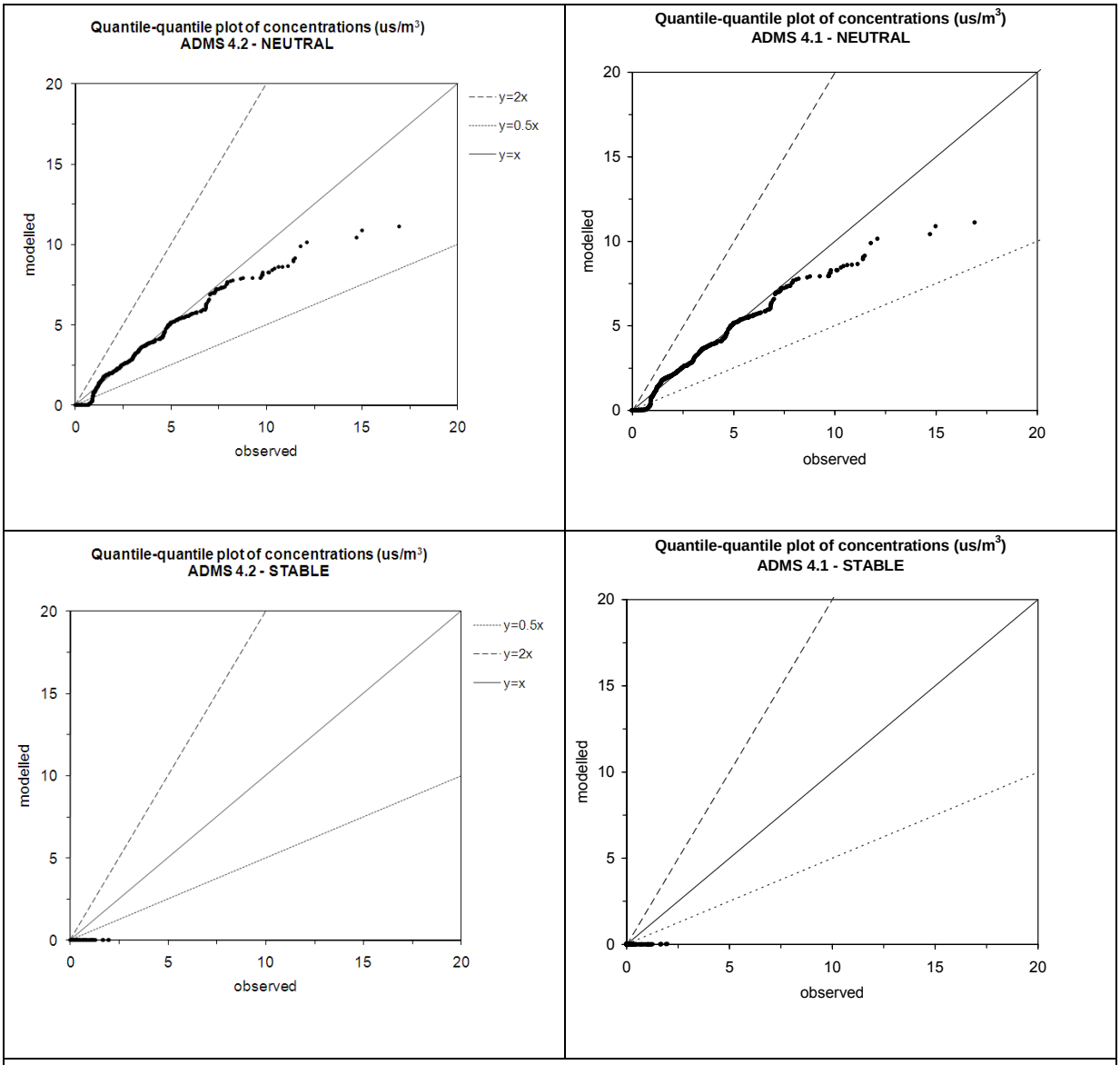

Figure 5 − Quantile-quantile plot of ADMS results against observed data for neutral and stable conditions (us/m^3).

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), 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). **Tables 3** and **4** show results from the BOOT package for all runs, for neutral and stable conditions respectively.

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 4.2	2.65	2.26	0.12	0.23	0.862	0.790	0.043	0.113
ADMS 4.1	2.65	2.26	0.12	0.23	0.862	0.790	0.043	0.113

Table 3 − BOOT statistics for neutral conditions.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
observed	0.14	0.32	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 4.2	0.00	0.00	0.14	4101.27	0.407	0.000	1.994	1.979
ADMS 4.1	0.00	0.00	0.14	4101.27	0.407	0.000	1.994	1.979

Table 4 − BOOT statistics for stable conditions.

4 Discussion

The differences between the concentrations predicted by ADMS 4.2 and ADMS 4.1 are negligible for the modelling of neutral conditions. ADMS 4 predicts the neutral observed concentrations very well, with the fraction of modelled results within a factor of 2 of the observed values being particularly good (0.79).

There is a significant difference in the NMSE value for both ADMS 4.2 and ADMS 4.1 when stable conditions are modelled. Both models significantly under-predict the concentrations observed in the wind tunnel. This is likely to be related questions over the simulation of the stable meteorological conditions in the wind tunnel facility.

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