

# ADMS 4 Buildings & Complex Terrain Validation *Baldwin Power Plant*

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## 1 Introduction

The Baldwin Power Plant<sup>1</sup> (Hanna and Chang [3]) was located in a rural, flat terrain setting of southwestern Illinois and had three identical 184-m stacks aligned approximately north-south with a horizontal spacing of about 100 m. There were 10 SO<sub>2</sub> monitors that surrounded the facility, ranging in distance from 2 to 10 km. On-site meteorological data were available during the study period of 1 April 1982 through 31 March 1983 and consisted of hourly averaged wind speed, wind direction and temperature measurements taken at 10 m, and wind speed and wind direction at 100 m.

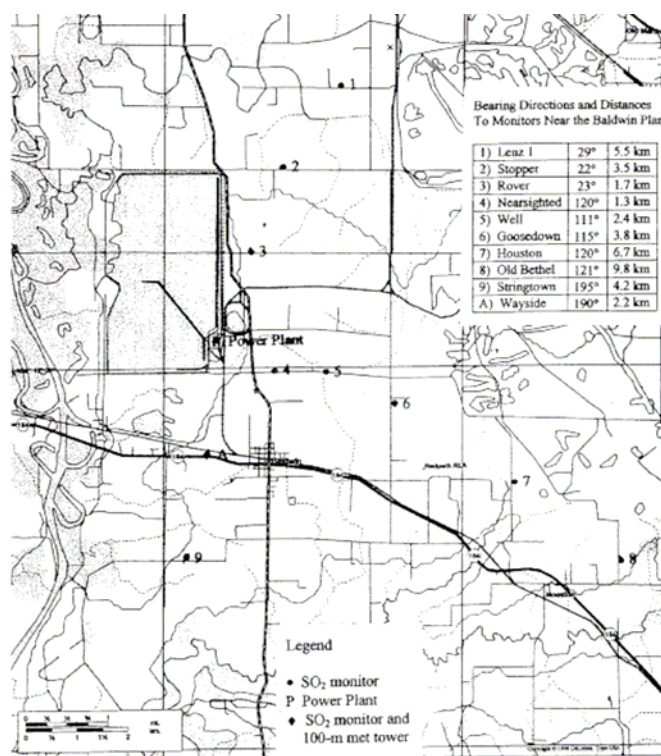


Figure 1 – Monitoring locations in the vicinity of the Baldwin power plant.

The input data for the ADMS runs were taken from the AERMOD files downloaded from the United States Environmental Protection Agency website [4]. These data included the observed concentrations that have been used for comparison with the ADMS modelled concentrations.

<sup>1</sup> Note that the study description has been taken directly from the document [1] and **Figure 1** from the document [2].

This document compares the results of ADMS 4.0.2.0 (further referred to as ADMS 4.0) with those of ADMS 3.3.1.0 (further referred to as ADMS 3.3).

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

### 2.1 Study area

The site is located at 38.2°N. The roughness length was dependent on wind direction and month. Its value ranged from 0.003 m (January to February, wind direction 255°-23°) to 0.190 m (June to September, wind direction 23°-255°).

Terrain data included in the modelling covered a 9 km × 9 km area centred on the source locations; terrain data points were located every 280 m within this area. **Figure 2** shows the modelled terrain area.

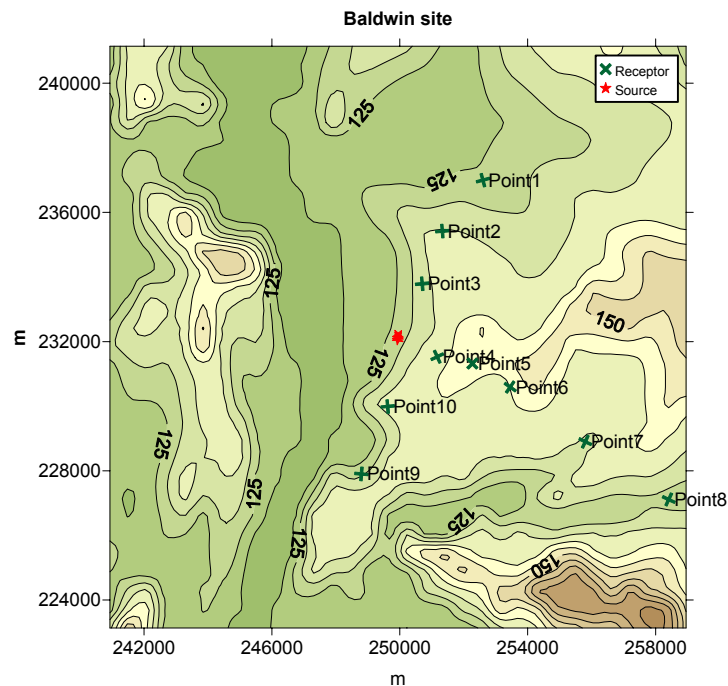


Figure 2 – Modelled terrain area around Baldwin power plant.

### 2.2 Source parameters

The source parameters are summarised in **Table 1**.

Source name	Pollutant	Location	Stack height (m)	Exit V (m/s)	Exit T (°C)	Diameter (m)	Emission rate (g/s)
stack1	SO <sub>2</sub>	249945, 232200	184.4	varied	varied	5.94	varied
stack2	SO <sub>2</sub>	249945, 232140	184.4	varied	varied	5.94	varied
stack3	SO <sub>2</sub>	249942, 232075	184.4	varied	varied	5.94	varied

Table 1 – Source input parameters. T is the temperature, V the velocity.

Exit velocities varied from 0 to 40.2 m/s, exit temperatures varied from 20 to 156°C and emissions rates varied from 0 to 4200 g/s.

### 2.3 Receptors

The receptor network consisted of 10 points, ranging from 2 to 10 km from the sources. All receptors were modelled as ground level receptors. **Figure 2** shows the receptor network in the experiment and **Table 2** summarises their locations.

Receptor name	Location
Point1	252600, 237000
Point2	251330, 235420
Point3	250700, 233790
Point4	251170, 231530
Point5	252270, 231320
Point6	253450, 230590
Point7	255800, 228900
Point8	258410, 227110
Point9	248800, 227900
Point10	249620, 229990

**Table 2** – Receptor point locations for Baldwin power plant site.

### 2.4 Meteorological data

The experiment used 1 year of hourly sequential data from the 1 April 1982 to 31 March 1983 measured at an on-site meteorological mast. **Table 3** gives the detail of the modelled meteorological conditions.

Conditions		ADMS 3.3	ADMS 4.0
Hours modelled	Stable conditions	5223 (60%)	5231 (60%)
	Neutral conditions	569 (7%)	547 (7%)
	Unstable conditions	2876 (33%)	2878 (33%)
	<i>Total</i>	<i>8668 (100%)</i>	<i>8656 (100%)</i>
Hours not modelled	Calm conditions	0	0
	Wind speed at 10 m < 0.75 m/s	92	104
	Inadequate data	0	0
	<i>Total</i>	<i>92</i>	<i>104</i>

**Table 3** – Meteorological conditions. Percentage values are computed with respect to the total number of modelled hours.

The wind speeds at 10 m varied from 0.3 to 13.6 m/s and the ambient temperature from -11.1 to 36.1°C. ADMS 4.0 also used the temperature and wind speed at 100 m entered via a meteorological profile file. The 10-m wind rose is shown in **Figure 3**.

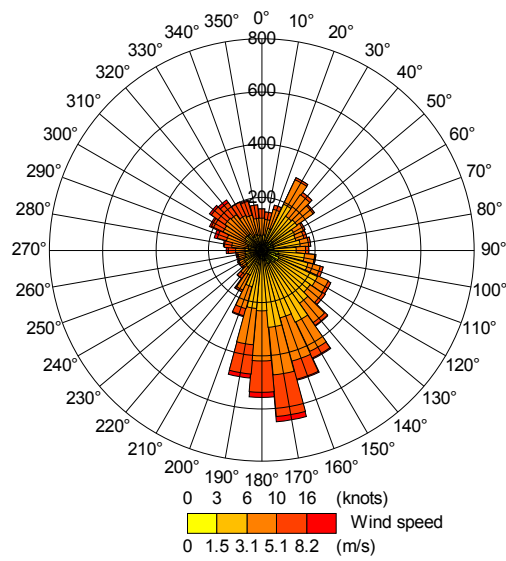


Figure 3 – Wind rose.

### 2.5 Buildings

The building dimensions are given in **Table 4**. The building location relative to the modelled stacks is shown in **Figure 4**.

Building name	Length (m)	Width (m)	Height (m)	Angle (°)
BLDG1	214	90	81.9	0

Table 4 – Dimensions of the building.

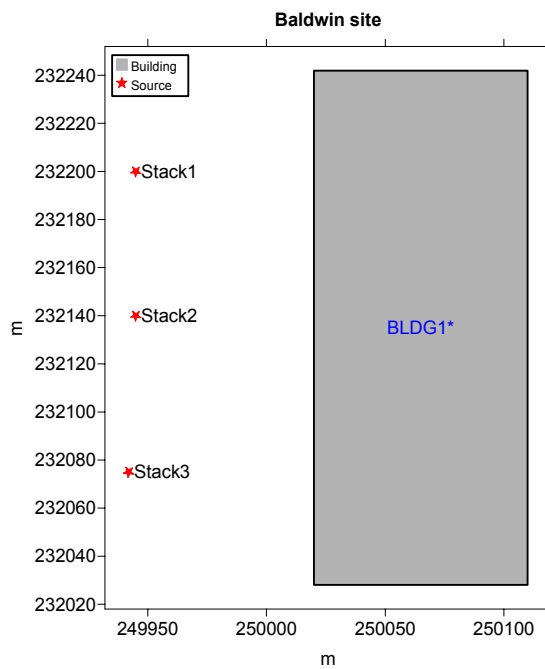


Figure 4 – The building and stack locations.

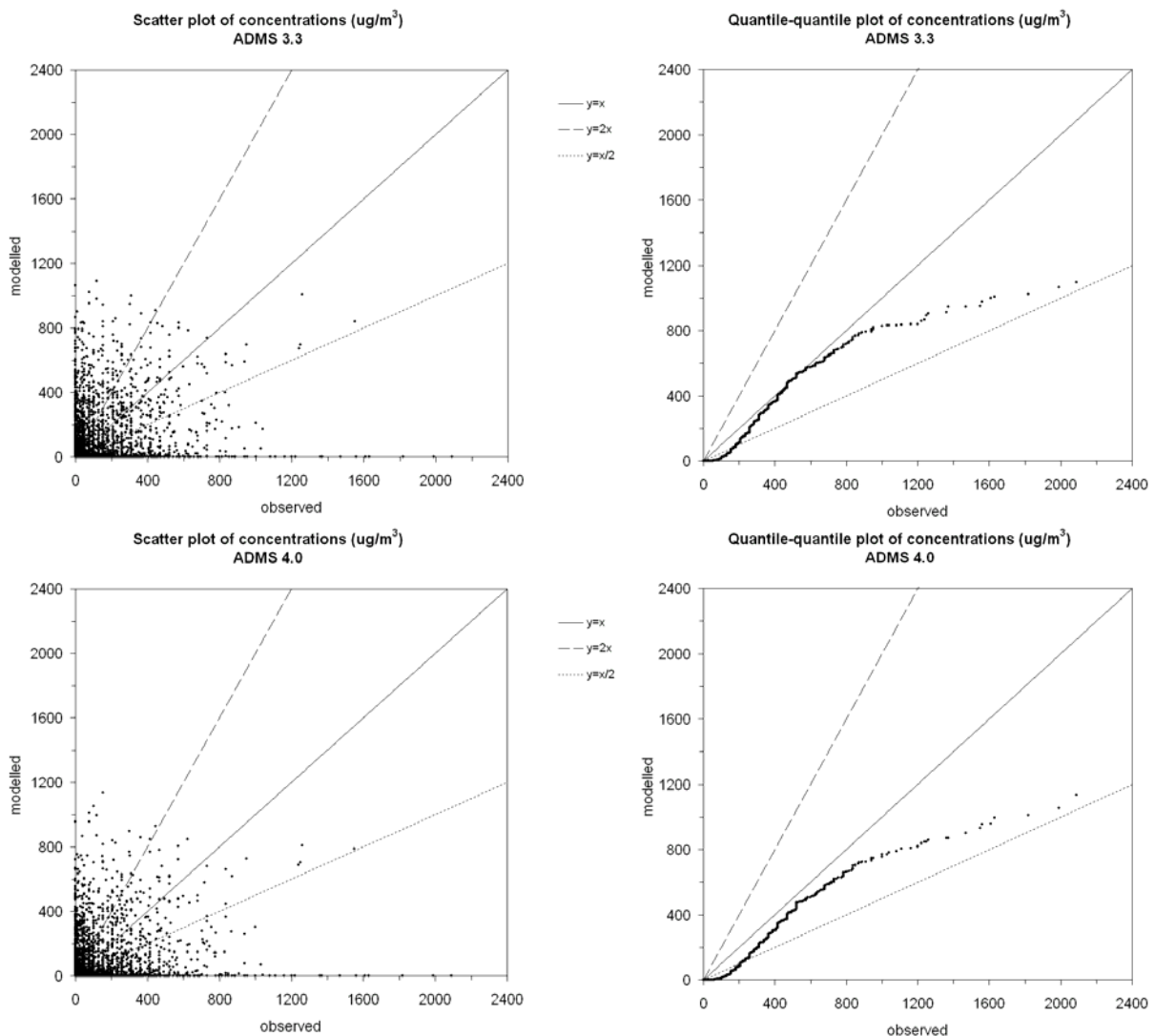
### 3 Results

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.

#### 3.1 Scatter and quantile-quantile plots

**Figure 5** shows the scatter plots and the quantile-quantile plots of 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 5** – Scatter plots and quantile-quantile plots of ADMS results against observed data ( $\mu\text{g}/\text{m}^3$ ).

#### 3.2 Statistics

**Table 5** compares the annual mean and maximum values at the receptor points.

**Table 6** compares the robust highest concentrations.

Statistics	Data	Concentrations (ug/m <sup>3</sup> )										Mean M/O ratio
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
1-hour max.	observed	1370	1630	1560	1990	1610	1200	1550	1250	2090	1470	-
	ADMS 3.3	1063	947	624	631	950	1023	1093	859	828	691	0.58
	ADMS 4.0	1134	899	619	743	955	1010	994	822	679	627	0.56
3-hour max.	observed	688	1007	755	1031	966	688	961	755	1037	1055	-
	ADMS 3.3	573	553	323	553	530	542	671	565	781	483	0.63
	ADMS 4.0	677	532	280	611	585	561	621	549	581	403	0.62
24-hour max.	observed	113	145	108	159	153	163	200	152	260	163	-
	ADMS 3.3	155	99	77	95	139	153	141	105	128	97	0.77
	ADMS 4.0	184	82	62	111	101	115	111	87	109	87	0.69
annual mean	observed	26.6	24.6	17.0	28.8	37.0	40.9	40.2	29.4	28.9	26.4	-
	ADMS 3.3	16.3	9.6	2.9	5.1	8.9	18.6	23.2	22.9	13.1	7.0	0.41
	ADMS 4.0	9.4	5.8	2.1	4.4	6.9	13.2	15.2	14.3	7.7	4.2	0.34

**Table 5** – Observed (O) and modelled (M) maximum concentrations and annual mean (ug/m<sup>3</sup>) per receptor point, and the mean ratio of modelled/observed values for each statistic.

Data	1-hour	3-hour	24-hour
ADMS 3.3	0.49	0.60	0.75
ADMS 4.0	0.50	0.63	0.72

**Table 6** – Ratio of modelled/observed robust highest concentrations (number of points = 26).

## 4 Discussion

The statistics presented in **Table 5** indicate that there may be some background unaccounted for, because whilst the model gives relatively good predictions of the 1-, 3- and 24-hourly maximum concentrations, the annual mean concentrations are under predicted. Preliminary investigations show that the background is of the order of magnitude of 5 µg/m<sup>3</sup>.

The scatter and quantile-quantile plots (**Figure 5**) show relatively good agreement between modelled and observed concentrations for both ADMS 3.3 and ADMS 4.0. The scatter plots compare predicted and measured concentrations at a particular location at a particular time, i.e. an (x,t) pairing. The quantile-quantile plots compare the distribution of predicted and measured concentrations during the period having abandoned the (x,t) pairing. Predicting the distribution of concentrations accurately is relevant to calculations for permitting purposes, where the comparison with air quality limits is more important than accurately predicting a time series of concentrations at each location. The latter is a harder task. In addition, the predictions of maximum concentrations presented in **Table 5** are good. The modelled annual average values are generally lower than those observed, but this is likely to be due to the issue with unaccounted background concentrations of SO<sub>2</sub>, as mentioned above.

ADMS 4.0 model predictions are slightly lower than those from version 3.3, which is reflected in the statistics presented in **Table 5**. However, it is interesting to note that the 1- and 3-hourly robust highest concentrations presented in **Table 6** are better for ADMS 4.0 than for ADMS 3.3, implying that ADMS 4.0 predicts the highest concentrations better than ADMS 3.3.

## 5 References

- [1] United States Environmental Protection Agency, 2003: *AERMOD, Latest Features and Evaluation Results*. EPA-454/R-03-003.
- [2] Paine, R.J, Lee, R.F, Brode, R, Wilson, R.B, Cimorelli, A.J., Perry, S.G., Weil, J.C., Venkatram, A, and Peters, W., 1998: *Model Evaluation Results for AERMOD (draft)*. United States Environmental Protection Agency.
- [3] Hanna, S.R. and J.C. Chang, 1993: *Hybrid Plume Dispersion Model (HPDM) Improvements and Testing at Three Field Sites*. In *Atmos. Envir.*, 27A, 1491-1508.
- [4] United States Environmental Protection Agency website, *Model Evaluation Databases*. [http://www.epa.gov/scram001/dispersion\\_prefrec.htm](http://www.epa.gov/scram001/dispersion_prefrec.htm)