

# ADMS 4 Complex Terrain Validation

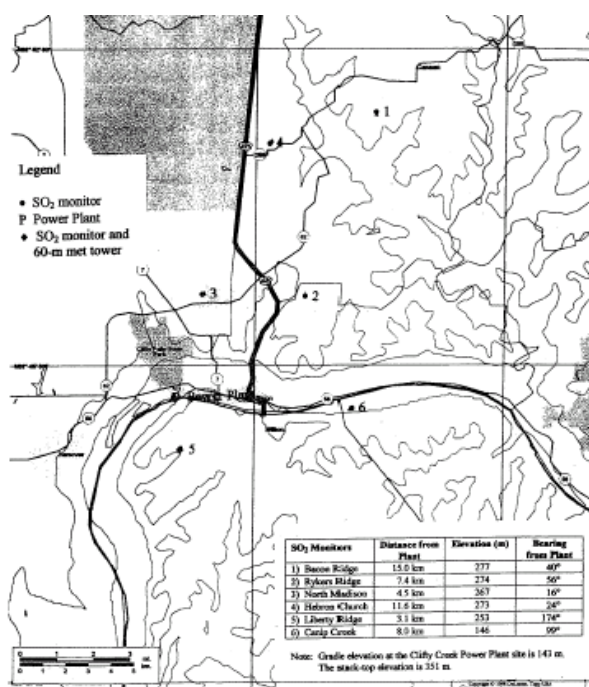
## Clifty Creek Power Plant

Cambridge Environmental Research Consultants  
June 2007

### 1 Introduction

The Clifty Creek power plant<sup>1</sup> is located in southern Indiana on the north side of the Ohio River (see **Figure 1**). The area immediately north of the facility is characterized by cliffs rising about 115 m above the river and intersected by creek valleys. The tops of the stacks extend about 80 to 100 m above the top of the cliffs on both sides of the river. Three 208-m stacks meters were modeled in this evaluation.

There were six SO<sub>2</sub> monitors on the surrounding terrain. One was located in the river valley approximately 8 km to the east (upriver) at about the same elevation as the sources. Another was located 3 km south of the facility on Liberty Ridge near the meteorological tower on the south side of the Ohio River and about 110 m above stack base. The remaining four monitors were located on the terrain north and north-east of the facility at about 125 m above the base of the stacks, ranging in distance from four to 15 km.



**Figure 1** – Monitoring locations in the vicinity of the Clifty Creek power plant.

Meteorological data from the Clifty Creek field study covered 1 January 1975 through to 31 December 1975. The on-site meteorological data were recorded on an instrumented

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

meteorological tower 3 km south of the facility (across the river in Kentucky) on Liberty Ridge.

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 includes the observed concentrations that are used for comparison with the ADMS modelled concentrations.

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.

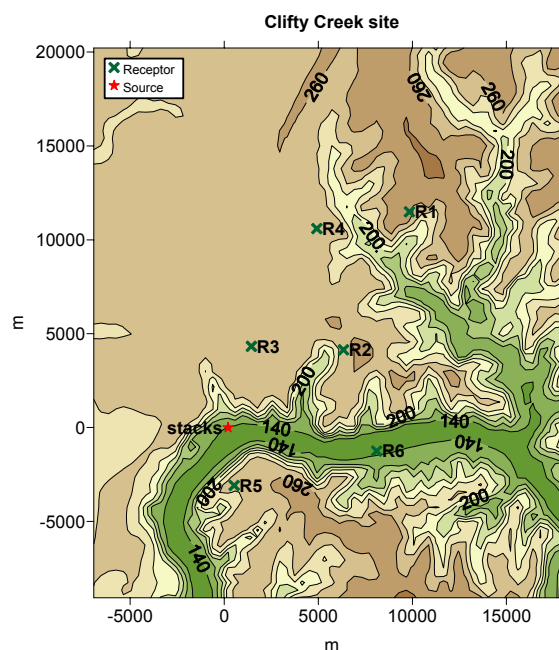
## 2 Input data

### 2.1 Study area

The study area is located around 38.7°N. The roughness length varies, depending on wind direction and month as shown in **Table 1**. Terrain data included in the modelling covered a 20 km × 28 km area (**Figure 2**) with terrain data points located every 300-400 m.

Time of the year	Wind sector	
	245-185°	185-245°
January to March	0.20	0.40
April to May	0.30	0.50
June to August	0.40	0.60
September to November	0.30	0.50
December	0.20	0.40

**Table 1** – Surface roughness length (m).



**Figure 2** – Modelled area around the Clifty Creek power plant. The meteorological tower is close to the R5 monitor.

## 2.2 Source parameters

The source parameters are summarised in **Table 2**. Exit velocities vary from 25.0-57.0 m/s. Stacks 2 and 3 have an exit velocity peak of 103.5 and 102.7 m/s respectively on the 299<sup>th</sup> day at 3:00AM (27 October 1975). Emissions rates vary from 3-3682 g/s.

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>	200, 0	207.9	varied	172.22	4.63	varied
Stack2	SO <sub>2</sub>	200, 0	207.9	varied	172.22	4.63	varied
Stack3	SO <sub>2</sub>	200, 0	207.9	varied	172.22	4.63	varied

**Table 2** – Source input parameters. T is the temperature, V the velocity.

## 2.3 Receptors

The receptor network consists of 6 monitors, ranging from 4 to 15 km from the sources. All receptors are modelled as ground level receptors. **Figure 2** shows the receptor network in the experiment and **Table 3** gives their spatial coordinates in a local coordinate system; for reference, the stacks are located at in (200,0).

Receptor name	Location
R1	9842, 11491
R2	6335, 4138
R3	1440, 4326
R4	4918, 10597
R5	524, -3083
R6	8102, -1251

**Table 3** – Receptor point locations.

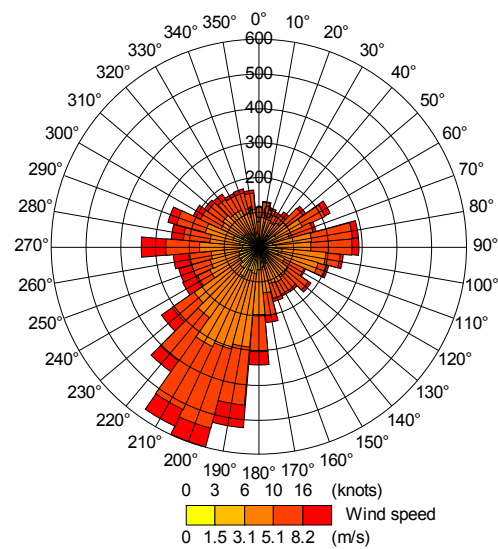
## 2.4 Meteorological data

One year of hourly sequential data from 1 January 1975 to 31 December 1975 was used. The wind rose is shown in **Figure 3**. **Table 4** gives the detail of the modelled conditions.

Conditions		ADMS 3.3	ADMS 4.0
Hours modelled	Stable conditions	5012 (59%)	5012 (59%)
	Neutral conditions	943 (11%)	943 (11%)
	Unstable conditions	2556 (30%)	2556 (30%)
	<i>Total</i>	<i>8511 (100%)</i>	<i>8511 (100%)</i>
Hours not modelled	Calm conditions	0	0
	Wind speed at 10 m < 0.75 m/s	248	248
	Inadequate data	1	1
	<i>Total</i>	<i>249</i>	<i>249</i>

**Table 4** – Meteorological conditions. Percentage values are computed with respect to the total number of modelled hours.

The wind speeds vary from 0.27 to 21.1 m/s and the surface temperature from -18.8 to 34.4°C. The height of the recorded wind measurement was 60 m. The wind rose is shown in **Figure 3**.



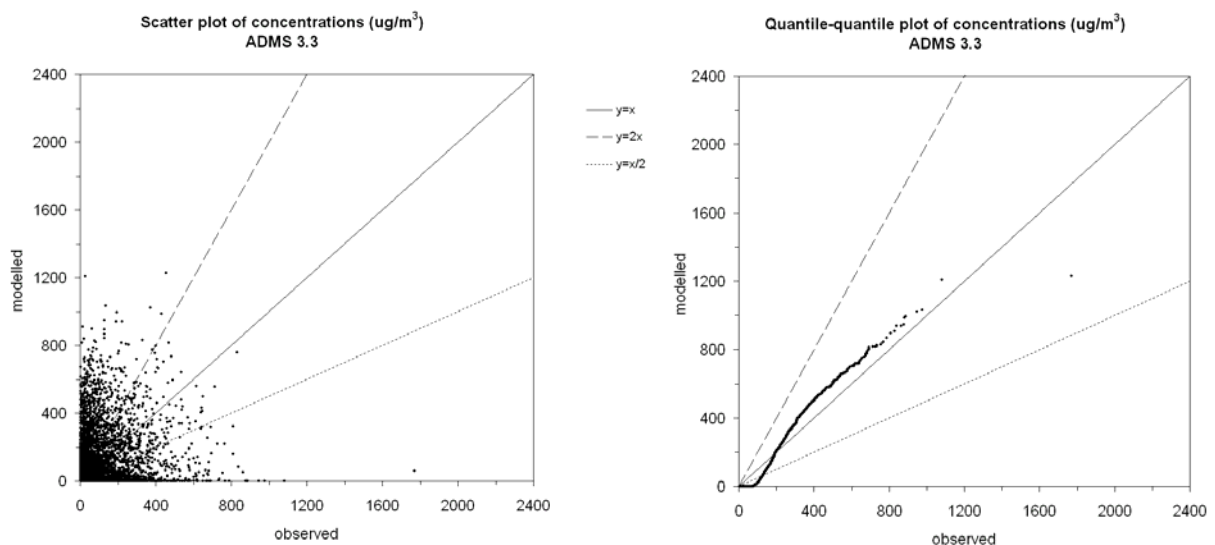
**Figure 3** – Wind rose from meteorological data.

### 3 Results

Scatter plots and quantile-quantile plots of model results against observed data are presented in Section 3.1. Other statistical analysis is presented in Section 3.2.

#### 3.1 Scatter and quantile-quantile plots

The modelled  $\text{SO}_2$  concentrations are compared to observed hourly concentrations ( $\mu\text{g}/\text{m}^3$ ). **Figure 4** shows the scatter plots and 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 4** – Scatter plots and quantile-quantile plots of ADMS results against observed concentrations ( $\mu\text{g}/\text{m}^3$ ).

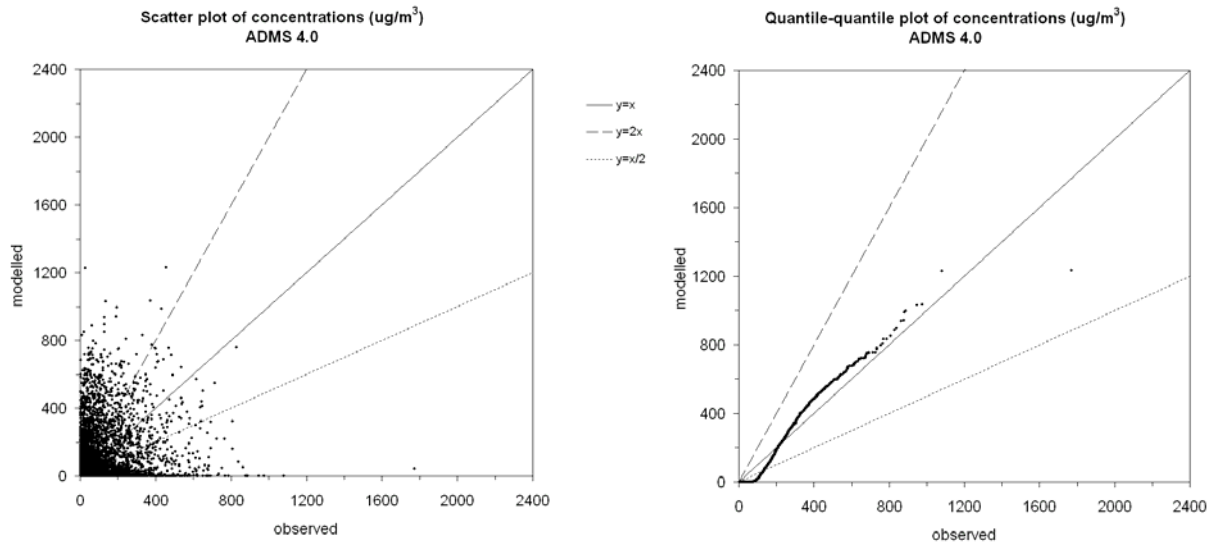


Figure 4 – continued.

### 3.2 Statistics

Table 5 compares the annual mean and maximum concentrations at each receptor point.

Table 6 compares the ratio of robust highest modelled/observed concentrations.

Statistics	Data	Concentrations (ug/m <sup>3</sup> )						Mean M/O ratio
		P1	P2	P3	P4	P5	P6	
1-hour maximum	observed	887	809	1772	976	692	1081	-
	ADMS 3.3	573	946	1229	739	939	938	0.92
	ADMS 4.0	586	937	1231	724	942	884	0.91
3-hour maximum	observed	579	536	857	613	384	632	-
	ADMS 3.3	526	717	840	589	569	778	1.15
	ADMS 4.0	489	692	846	579	557	736	1.11
24-hour maximum	observed	252	189	309	170	145	182	-
	ADMS 3.3	152	138	237	197	146	109	0.81
	ADMS 4.0	142	133	227	197	145	108	0.79
annual mean	observed	41.4	36.7	39.8	37.7	34.7	29.3	-
	ADMS 3.3	13.5	14.3	17.6	20.9	3.7	8.3	0.35
	ADMS 4.0	12.0	13.5	17.1	19.6	3.3	6.8	0.32

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	0.99	1.18	0.83
ADMS 4.0	0.98	1.15	0.85

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

## 4 Discussion

The graphs and tables presented in Section 3 show generally good prediction of the observed concentrations by ADMS. In particular, the high concentrations are well predicted – see for example the 1-, 3- and 24-hour maximum values presented in **Table 5**, and the robust highest concentration values presented in **Table 6**. The only statistic that is not well predicted by the model is the annual average. The most likely reason for this is that there is a background concentration of SO<sub>2</sub> present from sources that are not included in the study (SO<sub>2</sub> is a common pollutant from combustion processes). A background concentration would explain the large number of points for which the modelled value is zero, and the observation is non-zero. Analysis of observed concentration data at receptors upwind of the modelled sources would allow an estimate of the hourly background concentration; however, no such analysis has been performed in this study.

The differences in results between ADMS 3.3 and ADMS 4.0 are not significant.

## 5 References

- [1] 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.
- [2] 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)