ADMS 6 Buildings Validation
EOCR Study

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1 Introduction

The Experimental Organically Cooled Reactor (EOCR) study[1] (Start *et al.* [1]) involved the simultaneous release of three tracer gases (SF_6, F_{12}, and Freon-$12B_2$) at three levels around the EOCR test reactor building at the Idaho National Engineering Laboratory in southeast Idaho, USA.

The terrain was flat with low-lying shrubs. The main building was 25 m high with an effective width of 25 m.

The tracer releases typically occurred simultaneously and were conducted during 22 separate time periods. Tracer sampler coverage was provided at eight concentric rings at distances of about 50, 100, 200, 400, 800, 1200, and 1600 m from the release points (see **Figure 1**).

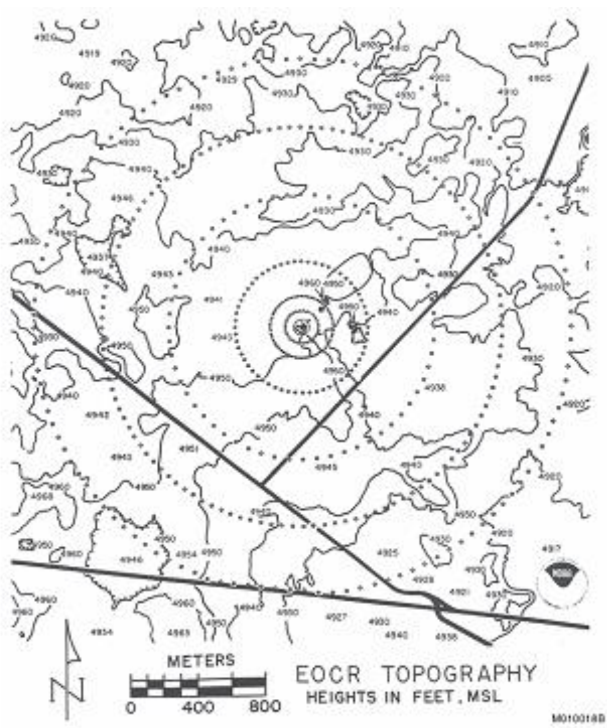

Figure 1 − EOCR study area.

Most of the meteorological data were measured on site and conditions were mainly unstable.

The input data for the ADMS runs were taken from the AERMOD files downloaded from the United States Environmental Protection Agency website [3].

These data included the arcwise maximum observed concentrations that have been used for comparison with the ADMS modelled concentrations. There were data for only 19 time periods and no data for the concentric ring distance of 200 m.

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

[1] Note that the study description and **Figure 1** have been taken directly from the document [2].

2 Input data

2.1 Study area

The latitude of the site is 43.5°N and the surface roughness was taken to be 0.1 m.

2.2 Source parameters

The source parameters are summarised in **Table 1**. Note that the 1 g/s emission rate indicates that the observed concentrations supplied in [3] have been normalised by the emission rate.

Source name	Pollutant	Location	h (m)	V (m/s)	T (°C)	D (m)	Q (g/s)
Roof	SF_6	(-8.22, 0.00)	25	0	ambient	0.5	1
Stack (S1)	SF_6	(9.40, 1.00)	30	0	ambient	0.5	1
SW	SF_6	(-22.00, -5.50)	1	0	ambient	0.5	1
NW	SF_6	(-22.00, 5.50)	1	0	ambient	0.5	1
NE	SF_6	(10.00, 17.00)	1	0	ambient	0.5	1

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

2.3 Receptors

The receptor network consisted of radially spaced points at 10° intervals. The receptors were located at approximately 50, 100, 400, 800, 1200 and 1600 m from the sources (**Figure 2**).

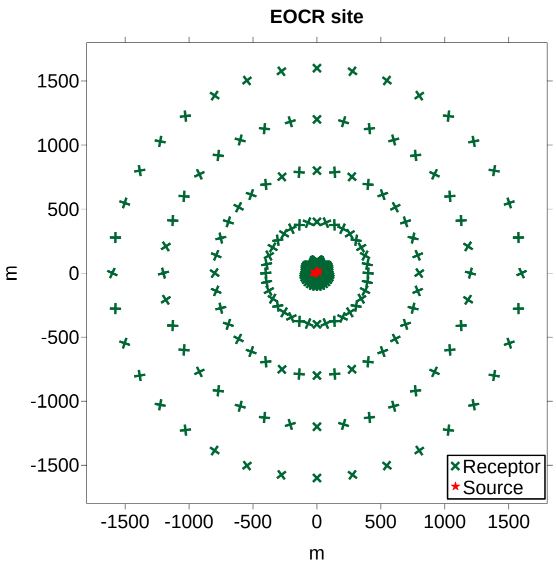

Figure 2 − The receptor network for EOCR site.

2.4 Meteorological data

Apart from the cloud cover obtained from a meteorological station 80 km to the south-west of the facility, the meteorological data were measured on site. **Table 2** gives details of the modelled meteorological conditions.

The criteria for the stability categories are as follows, where H is the boundary layer height and L_{MO} is the Monin-Obukhov length, as calculated by the model's meteorological processor:

$$\text{Stable: } H/L_{MO} > 1$$
$$\text{Neutral: } -0.3 \leq H/L_{MO} \leq 1$$
$$\text{Convective: } H/L_{MO} < -0.3$$

Conditions	ADMS 5.2	ADMS 6.0
Stable conditions	5	5
Neutral conditions	1	1
Unstable conditions	13	13
Total	*19*	*19*

Table 2 – Meteorological conditions.

The ADMS 6.0 option to calculate the solar elevation at the end of the met. hour (same behaviour as ADMS 5.2) rather than at the middle of it was used. This was done because the times in the meteorological file are already centred rather than hour-ending in this instance.

The ambient temperature varied from -0.22 to 25.53°C and the wind speeds at 10 m from 0.8 to 8.1 m/s. The model also used the recorded wind and temperature at heights of 4, 10 and 30 m. The wind rose for the 10 m wind data is shown in **Figure 3**.

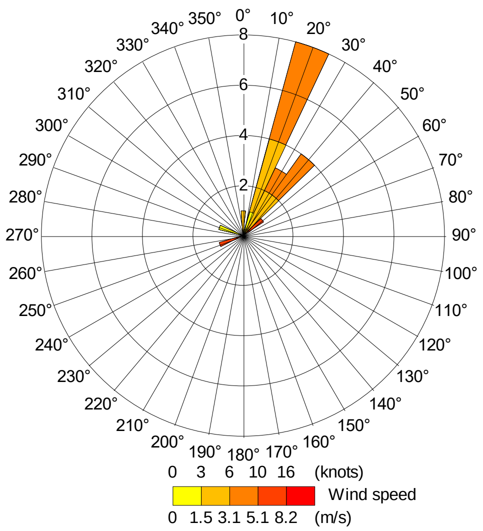

Figure 3 – Wind rose.

2.5 Buildings

The building dimensions are given in **Table 3**. The building locations relative to the modelled stacks are shown in **Figure 4**. The 'Tall' building was assigned as the main building for all sources, apart for the NE source where the 'Short' building was the main building.

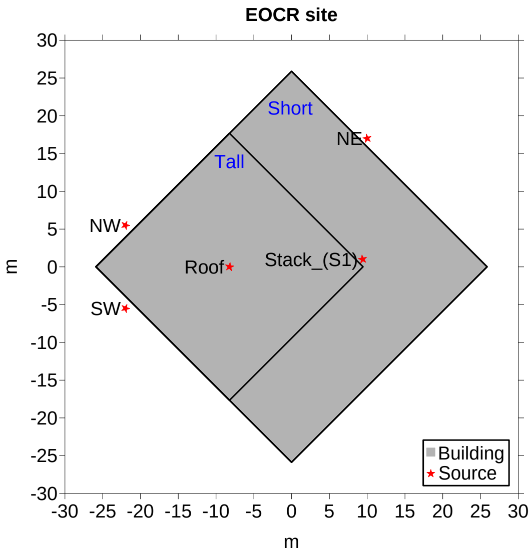

Figure 4 − Building and stack locations.

Building name	Length (m)	Width (m)	Height (m)	Angle (°)
Tall	25.0	25.0	25.0	45
Short	36.6	36.6	7.0	45

Table 3 – Dimensions of the buildings.

3 Results

For this experiment, arc maximum modelled and observed concentration values are compared. Two sets of 'observed' data are supplied with the AERMOD data [3]: "fitted" and "actual". The "actual" data are the values that were observed at the receptors. The "fitted" values are concentrations that have been adjusted using the data for the whole receptor arc; this adjustment is intended to account for the fact that models are calculating ensemble means and are not taking into account stochastic variation due to short term atmospheric turbulence. In general, the "fitted" values are lower than the "actual" values.

Scatter plots and quantile-quantile plots of model results against both "actual" and "fitted" observed data are presented in Section 3.1. Other statistical analysis of the model results with both "actual" and "fitted" observed data are given in Section 3.2. The graphs and statistical analysis have been produced by the Model Evaluation Toolkit v5.2 [4].

3.1 Scatter and quantile-quantile plots

Figure 5 and **Figure 6** show the scatter plots and quantile-quantile plots of results, presented on logarithmic scales.

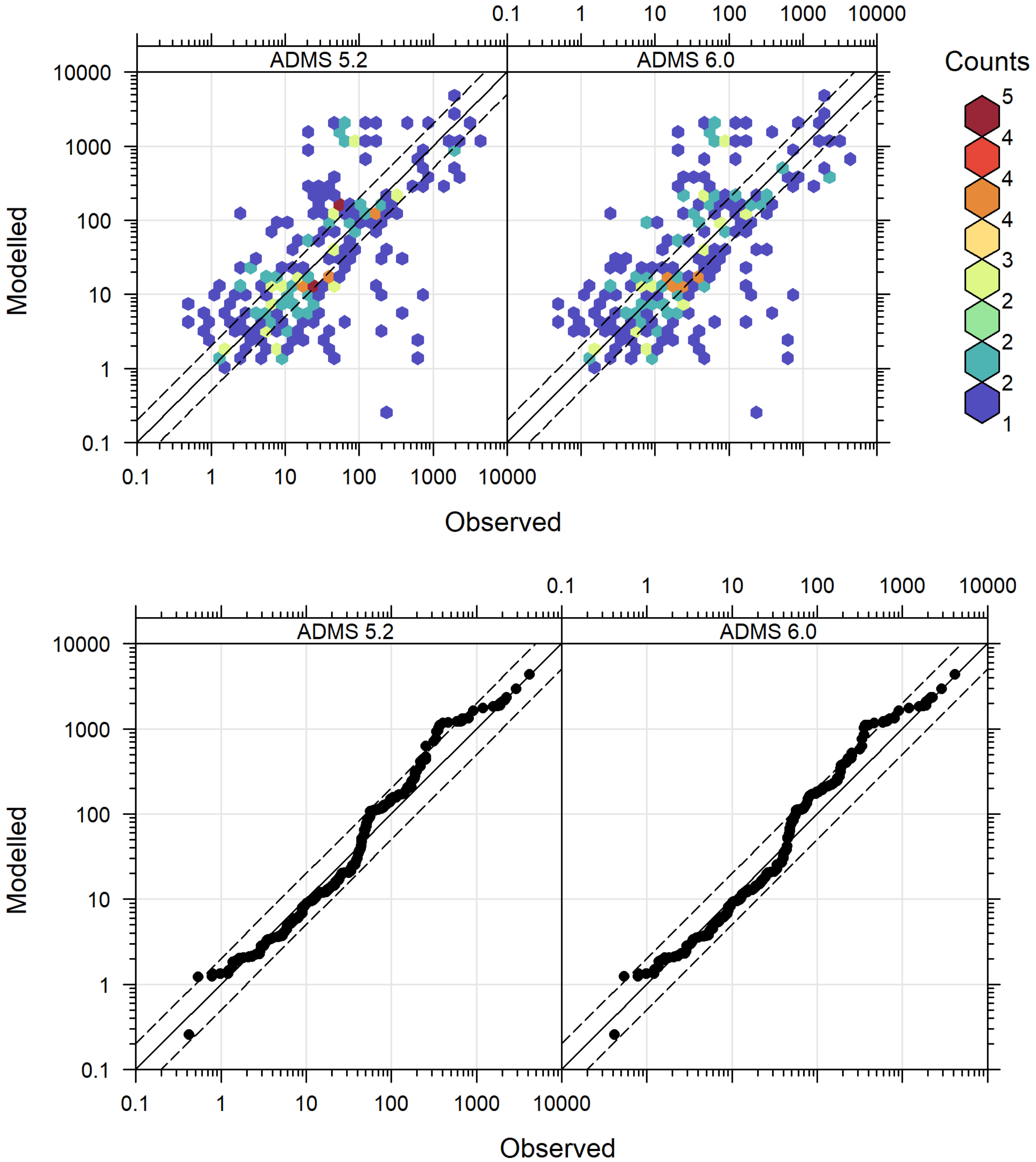

Figure 5 − Scatter and quantile-quantile plots of ADMS results against actual observed data (ug/m^3).

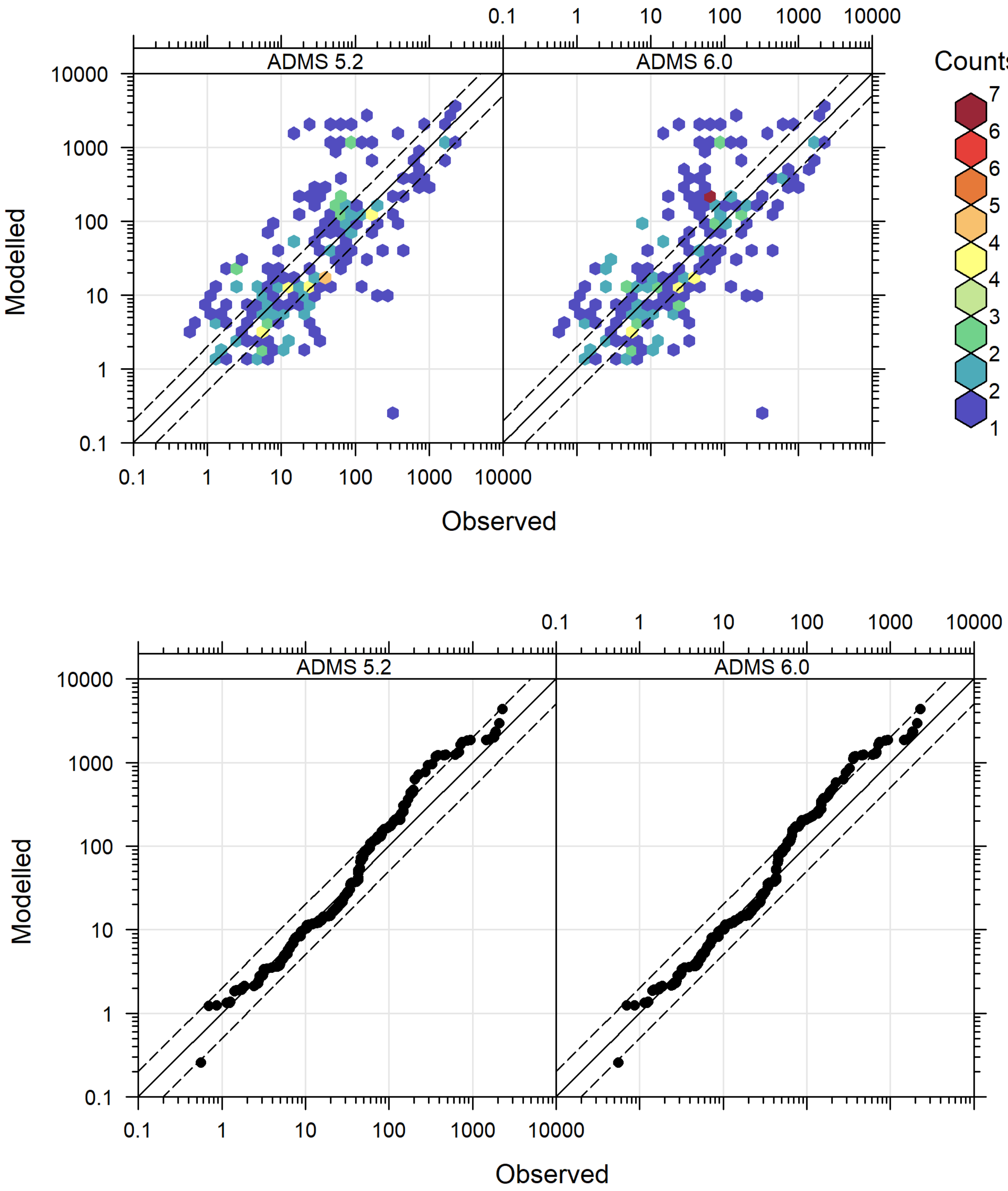

Figure 6 - Scatter plots and quantile-quantile plots of ADMS results against fitted observed data (us/m^3).

3.2 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).

Tables 4 and **5** show the statistical results for all sources against "actual" and "fitted" observed data.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
Observed	174.40	481.81	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 5.2	235.49	556.23	61.09	6.89	0.489	0.426	0.298	0.143
ADMS 6.0	239.59	557.30	65.19	7.46	0.438	0.410	0.315	0.145

Table 4 − Summary statistics of model performance against "actual" observed data (ug/m^3).

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
Observed	140.86	357.75	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 5.2	245.90	572.35	105.04	5.99	0.633	0.429	0.543	0.461
ADMS 6.0	249.39	573.20	108.53	6.64	0.573	0.406	0.556	0.463

Table 5 – Summary statistics of model performance against "fitted" observed data (us/m^3).

4 Discussion

ADMS gives generally good agreement between modelled and observed concentrations, although the model has a tendency to over-predict the observed data (both "fitted" and "actual").

The scatter and quantile-quantile plots shown in Section 3.1 indicate that there are only minor difference between ADMS 5.2 and ADMS6.0. The statistics in Section 3.2 show that ADMS 6.0 tends to predict slightly higher mean concentrations than ADMS 5.2, which are slightly further from the observed values. The following ADMS 6.0 code developments are responsible for the changes in results:

1. The ground-level plume emanating from recirculation region is now modelled as a line source rather than a point source, with an initial concentration that is better matched to the uniform concentration of the entrained part of the plume within the well-mixed recirculation region.
2. The dispersion pattern of plumes that directly impact the upwind face of a building has been altered, with more material passing around and over the building rather than passing through it.

5 References

[1] Start, G.E., N.F. Hukari, J.F. Sagendorf, J.H. Cate, and C.R. Dickson, 1981: *EOCR Building Wake Effects on Atmospheric Diffusion*. NUREG/CR-1395, National Oceanic and Atmospheric Administration, Idaho Falls, ID.

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

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

[4] 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.

[5] 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

[6] 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/

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