

ADMS 4 Buildings Validation

Millstone Nuclear Power Plant

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1 Introduction

A series of tracer releases was carried out at the Millstone nuclear power plant¹ located near Niantic on the Connecticut coast [2]. Each release comprised an hour-long continuous emission of SF₆ from a stack at 48.3 m or of Freon-12 from three stacks at 29.1 m. A total of 36 releases of SF₆ and 26 releases of Freon-12 were carried out. Concentrations were measured at 38 receptor locations along three arcs. The experimental set-up is illustrated in **Figure 1**.

Meteorological measurements were made at an on-site tower, at heights of 10 and 43 m. The majority of the releases were carried out during stable or neutral conditions. Winds were predominantly on-shore, with generally high speeds. The wind speed exceeded 7 m/s for most hours and reached more than 10 m/s for several of the release periods.

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.

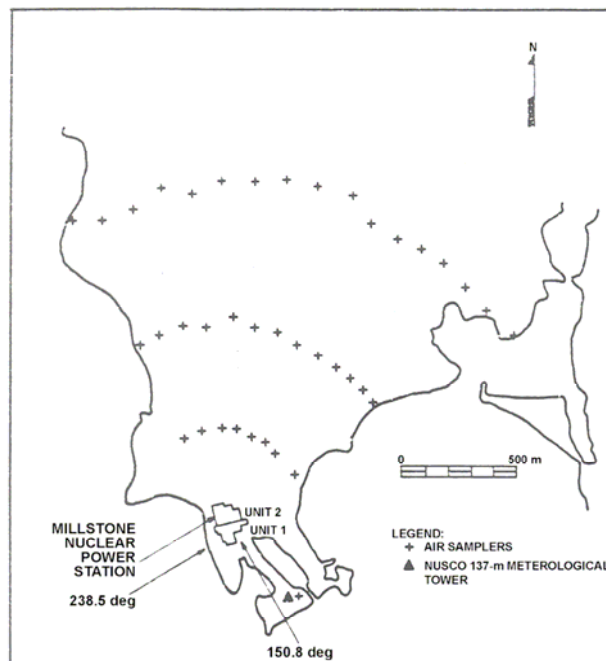


Figure 1 – Millstone experiment site.

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

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 41.31°N and the surface roughness is 0.010 m. This relatively low surface roughness chosen for the model runs was due to the close proximity of the experimental site to the sea, and fact that the winds were predominantly from the direction of the sea.

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)	Effective D (m)	Emission rate (g/s)
REAC (reactor stack)	SF ₆	(0,0)	48.3	varied	varied	2.12	1
TURB1 (turbine stack)	Freon-12	(-77, 32)	29.1	varied	varied	1.4	1
TURB2 (turbine stack)	Freon-12	(-66, -5)	29.1	varied	varied	1.4	1
TURB3 (turbine stack)	Freon-12	(-53, -50)	29.1	varied	varied	1.4	1

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

Emission temperatures were different for each of the releases, but were all close to ambient temperature at around 21.9°C. Similarly, release velocities varied for different hours, but were all close to 10 m/s.

Note that the 1 g/s emission rate indicates that the observed concentrations supplied in [3] have been normalised by the emission rate.

2.3 Receptors

The receptors were positioned in three arcs at distances of 350, 800 and 1500 metres downwind of the sources, as shown in **Figure 4**.

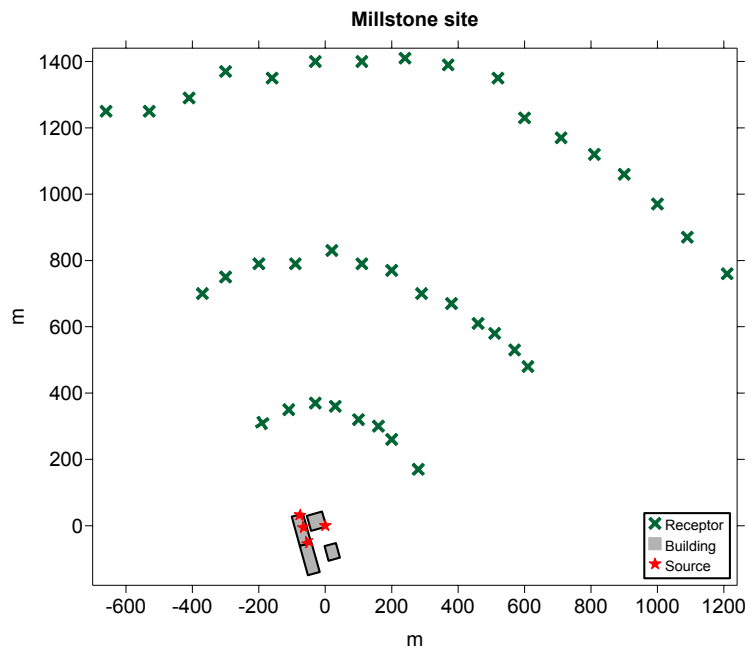


Figure 2 – The receptor network.

2.4 Meteorological data

During the Millstone experiment there were 17 stable, 17 neutral and 2 convective conditions. At 43.3 m, the wind speeds varied from 3.4 to 12.6 m/s, the wind direction from 147 to 232° and the ambient temperature from 8.9 to 17.9°C. The height of the recorded wind used was 43.3 m. The wind speed at 10 m was also used by the model. The wind rose is shown in **Figure 3**.

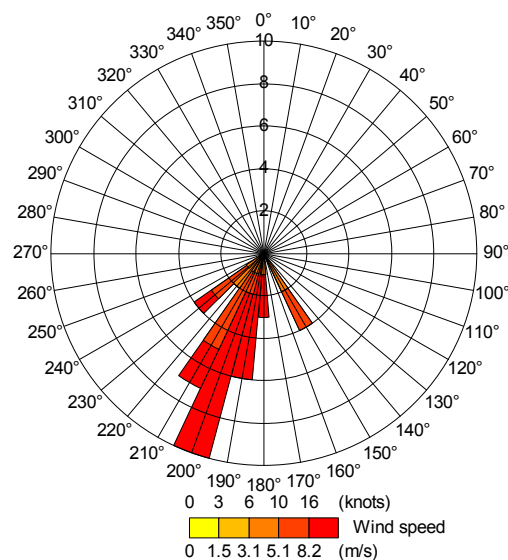


Figure 3 – Wind rose.

2.5 Buildings

The building dimensions are given in **Table 2** and their location relative to the modelled stacks are shown in **Figure 4**.

Building name	Length (m)	Width (m)	Height (m)	Angle (°)
Reactor1	47.8	47.8	44.7	344.2
Reactor2	45.6	35.4	41.6	344.8
Turbine1	92.4	36.7	27.6	344.3
Turbine2	91.2	35.4	27.6	344.8

Table 2 – Dimensions of the buildings.

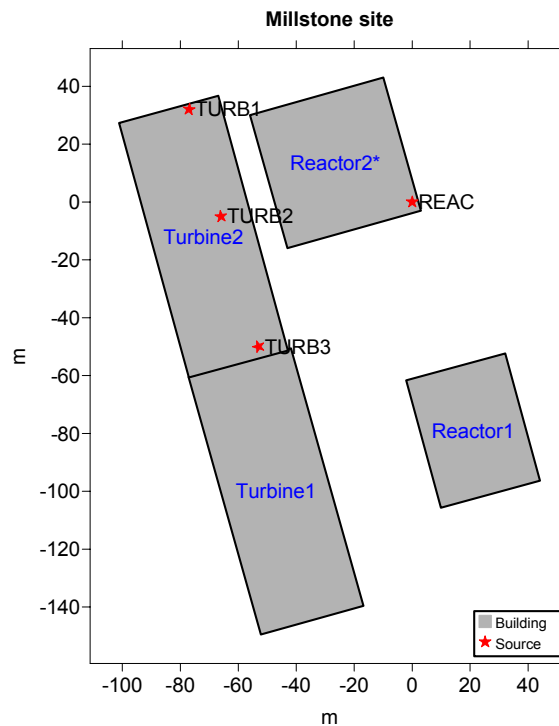


Figure 4 – The building and stack locations.

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 5 show the scatter plots and the quantile-quantile plots of ADMS results for Freon-12 and SF₆. Note that these quantile-quantile plots are linear; care should be exercised when comparing these plots with similar ones presented with logarithmic axes.

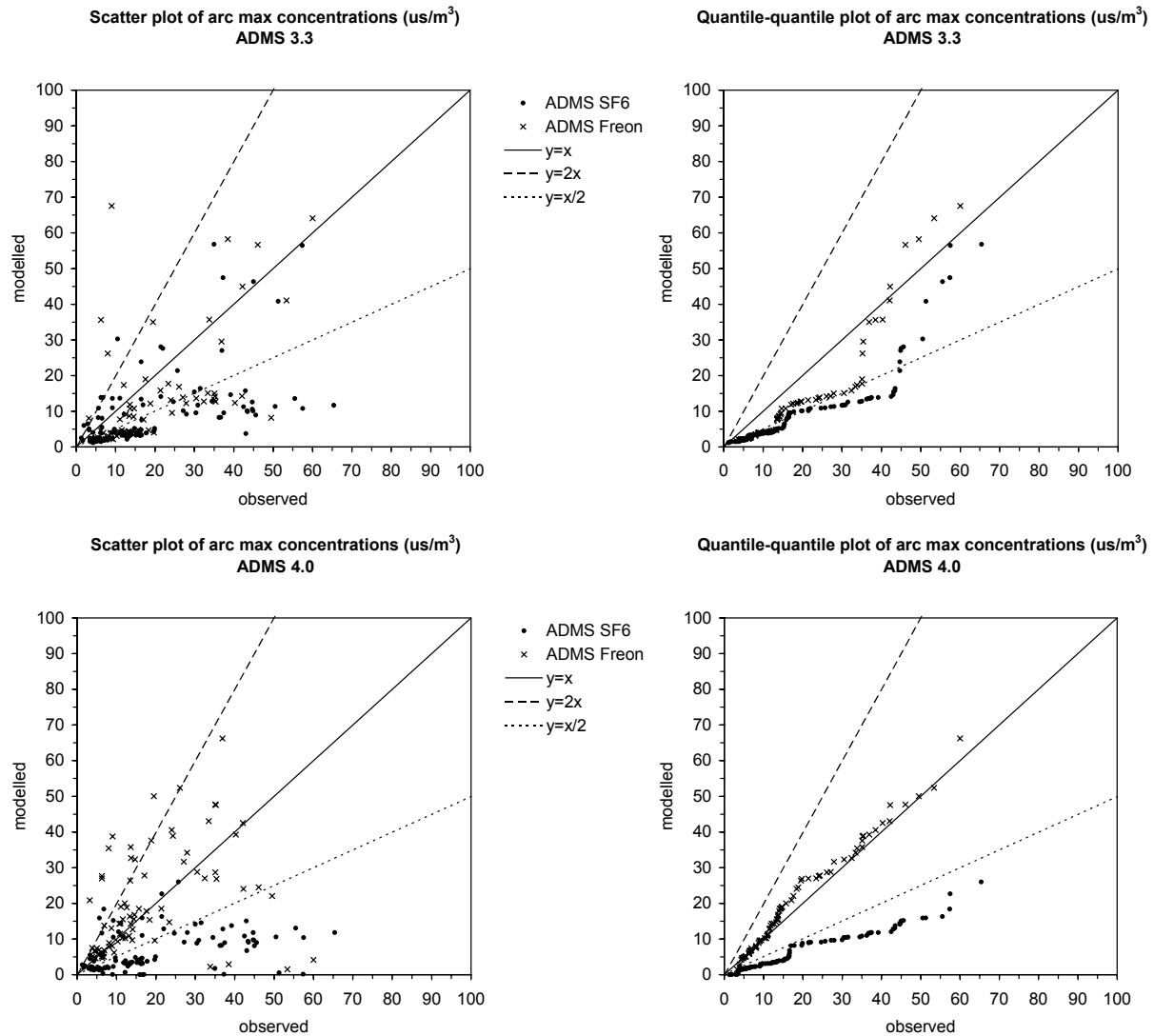


Figure 5 – Scatter plots and quantile-quantile plots of ADMS results against observed concentrations ($\mu\text{s}/\text{m}^3$).

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).

Table 3 shows the results from the BOOT package for both pollutants. **Tables 4** and **5** show the results from the BOOT package for the Freon-12 and SF₆ releases, respectively.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
observed	18.58	14.81	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 3.3	10.70	12.83	7.88	1.19	0.551	0.328	0.538	0.143
ADMS 4.0	11.88	12.19	6.70	1.42	0.276	0.446	0.440	0.194

Table 3 – BOOT statistics for both pollutants together over all arcs.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
observed	18.17	13.30	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 3.3	12.56	14.87	5.61	0.83	0.606	0.359	0.365	-0.111
ADMS 4.0	19.92	14.24	-1.75	0.65	0.388	0.795	-0.092	-0.068

Table 4 – BOOT statistics for Freon-12 over all arcs.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
observed	18.88	15.80	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 3.3	9.37	10.94	9.51	1.53	0.547	0.306	0.674	0.363
ADMS 4.0	6.07	5.39	12.81	3.22	0.434	0.194	1.026	0.982

Table 5 – BOOT statistics for SF₆ over all arcs.

4 Discussion

It is of interest to note that there is significantly different behaviour in the results between the Freon-12 and SF₆ observed values. As this behaviour is also seen in the AERMOD modelling of this experiment (see for example Figures 10 and 11 in [1]), it is likely that there may be some systematic difference in the quantification of the observed data for the different pollutants used in the experiments.

There is generally good agreement between ADMS modelled and observed concentration values with much better agreement for the Freon-12 observed concentrations than the SF₆ values. The latter observed data are under-estimated by ADMS.

Comparison of the statistics for ADMS 3.3 and ADMS 4.0 (**Table 3**), ADMS 4.0 is seen to perform better for the mean and the fraction within a factor of 2 of the observed value. ADMS 4.0 performs better for the Freon-12 observed values, and ADMS 3.3 performs better for the SF₆ values.

5 References

- [1] United States Environmental Protection Agency, 2003: *AERMOD, Latest Features and Evaluation Results*. EPA-454/R-03-003.
- [2] Bowers, J.F. and A.J. Anderson, 1981: *An Evaluation Study for the Industrial Source Complex (ISC) Dispersion Model*. Report EPA-450/4-81-002. NTIS #PB81-176539. United States Environmental Protection Agency Office of Air Quality Planning and Standards.
- [3] United States Environmental Protection Agency website, *Model Evaluation Databases*. http://www.epa.gov/scram001/dispersion_prefrec.htm