ADMS 6 Buildings Validation
AGA Experiments

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1 Introduction

The American Gas Association (AGA) experiments[1] [1] occurred during spring and summer 1978 at gas compressor stations in Texas and Kansas. At each test facility, one of the gas compressor stacks was retrofitted to accommodate SF_6 tracer gas emissions. In addition, stack height extensions were provided for some of the experiments (with the normal stack height close to 10 m). The stack height to building height ratios for the tests ranged from 0.95 to 2.52.

There were a total of 63 tracer releases over the course of the tests, and the tracer samplers were located between 50 and 200 m away from the release point. **Figure 1** shows the experimental set up at the Kansas site.

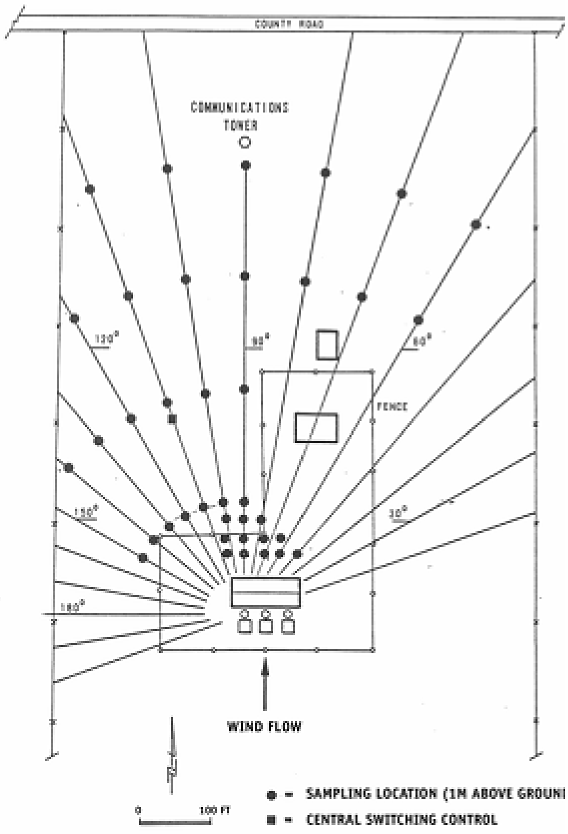


Figure 1 – AGA study area, locations of tracer samples at Kansas site.

An instrumented 10-m tower was operated at both experimental sites. The tracer releases were generally restricted to daytime hours. Meteorological conditions were mainly unstable. Wind speeds ranged from 2 to 11 m/s over the 35 hours.

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.

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 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

Two sites were investigated during this study: one in Texas and one in Kansas. **Table 1** summarises the study area parameters for both sites.

Parameter	Texas site	Kansas site
Surface roughness (m)	0.1	0.1
Latitude (degrees, N)	29.0	38.2

Table 1 – Study area parameters for both sites.

2.2 Source parameters

The source parameters are summarised in **Table 2**. Each source is modelled separately for different hours. Note that the 1 g/s emission rate indicates that the observed concentrations supplied in [3] have been normalised by the emission rate.

At the Texas site, the exit velocity values were either 8.8 m/s or 15.2 m/s and the exit temperature either 363°C or 371°C, for each of the stacks for the various experiments.

Site	Source name	Pollutant	Location	Stack height (m)	Exit V (m/s)	Exit T (°C)	Diameter (m)	Emission rate (g/s)
Texas	Stack1	SF_6	(5.8, -3.3)	9.75	varied	varied	0.61	1
	Stack2	SF_6	(5.8, -3.3)	14.48	varied	varied	0.61	1
Kansas	Stack1	SF_6	(28.5, -5.0)	9.80	8.1	343	0.61	1
	Stack2	SF_6	(34.4, -5.0)	24.40	8.1	343	0.61	1

Table 2 – Source input parameters for both sites. T is the temperature, V the velocity.

2.3 Receptors

The receptor network at each of site consisted of radially spaced monitors (**Figure 2**).

For the Texas site, receptors were located at distances of 50 m, 100 m, 150 m and 200 m from the source. The measured wind directions during the experiment ranged from 60° to 180°.

For the Kansas site, receptors were located at distances of 100 m, 150 m and 200 m from the source. The measured wind direction during the experiment ranged from 165° to 210°.

2.4 Meteorological data

Table 3 shows the meteorological conditions on the site during both the Texas and the Kansas experiment. 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:

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

	Texas site		Kansas site	
Conditions	**ADMS 5.2**	**ADMS 6.0**	**ADMS 5.2**	**ADMS 6.0**
Stable	1	1	3	3
Neutral	0	0	0	0
Convective	22	22	9	9

Table 3 – Meteorological conditions.

During the Texas experiment the wind speeds varied from 3.3 to 10.3 m/s, the ambient temperature from 12.8 to 32.8°C and the wind direction between 60° and 180°. During the Kansas experiment, the wind speeds varied from 1.3 to 6.7 m/s, the ambient temperature from 20.8 to 38.8°C and the wind direction between 165 and 210°. **Figure 3** shows the wind roses for both sites. For both experiments, the height of the recorded wind was 10 m.

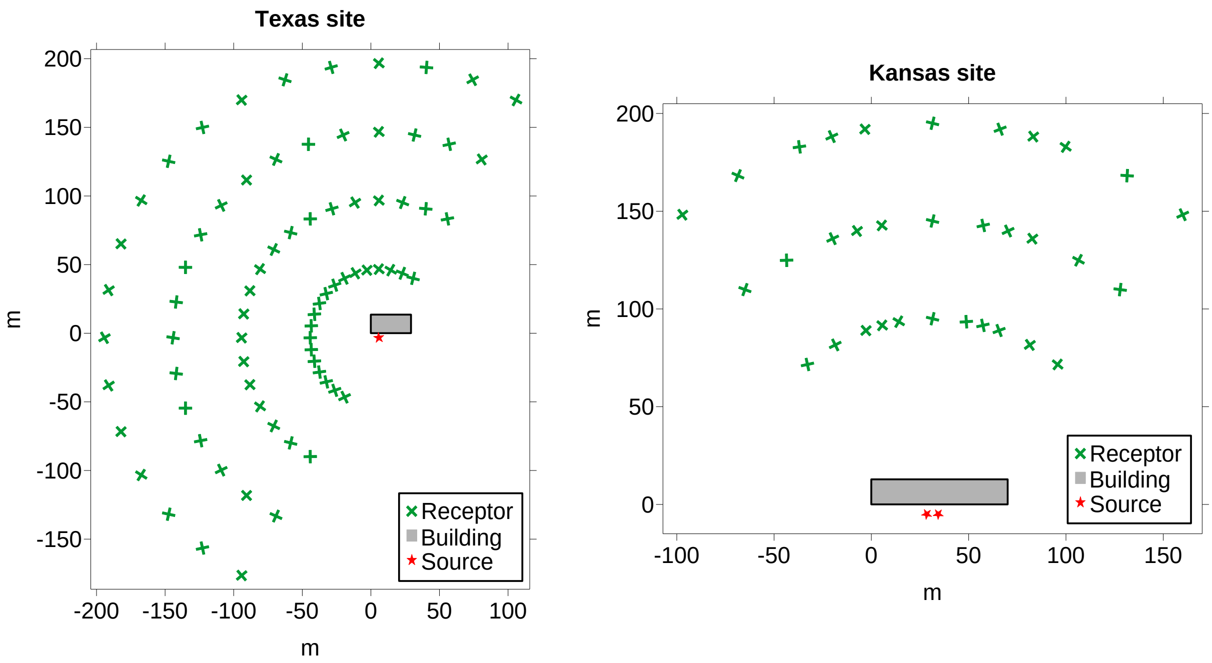


Figure 2 – The receptor network for Texas site (left) and Kansas site (right).

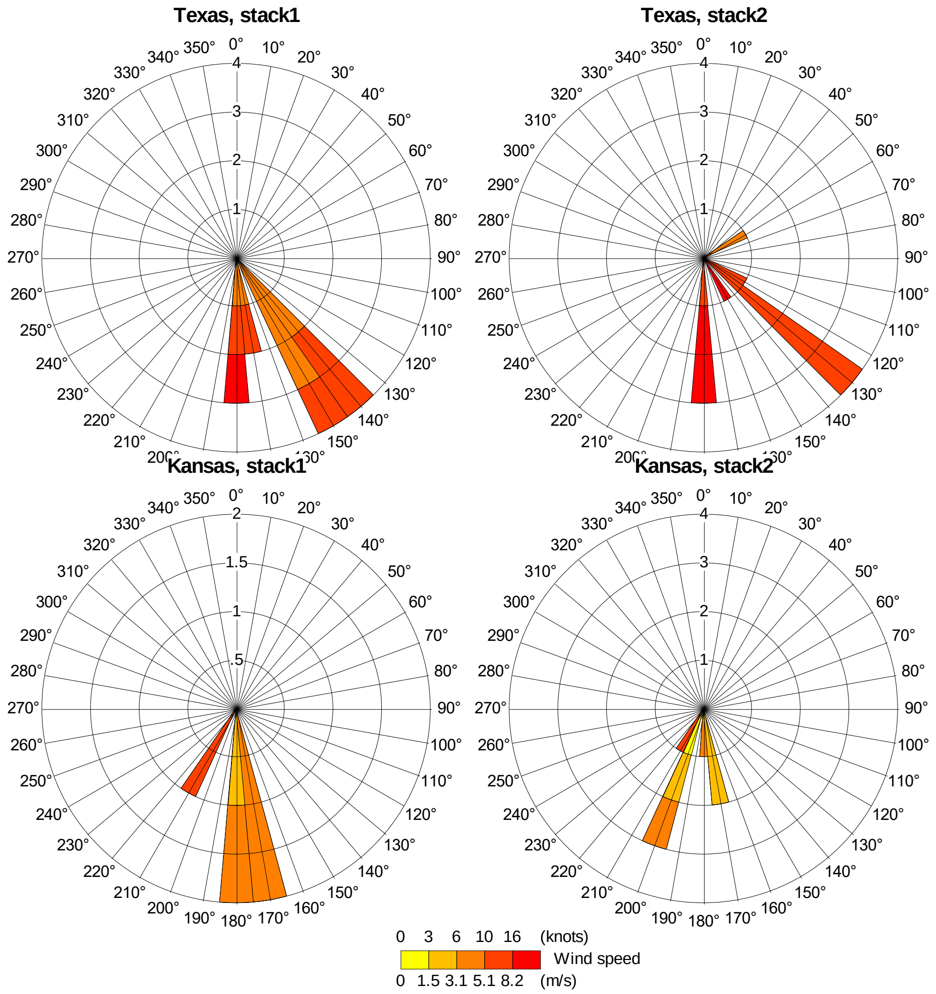


Figure 3 − Wind roses for the Texas and Kansas sites.

2.5 Buildings

The building dimensions are given in **Table 4**. The building locations relative to the modelled stacks are shown in **Figure 4** (a local coordinate system has been used at each site).

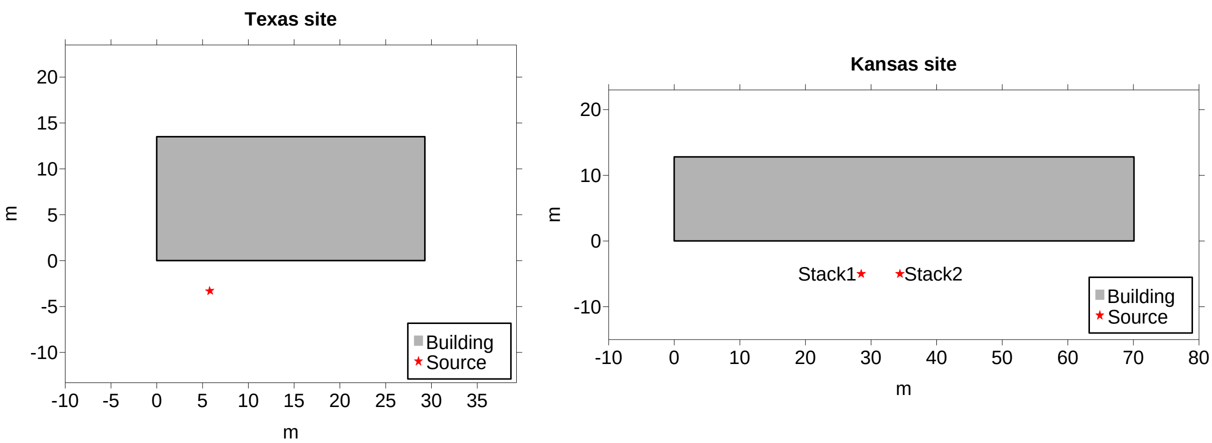


Figure 4 − The building and stack locations for the Texas site (left) and the Kansas site (right).

Site	Length (m)	Width (m)	Height (m)
Texas	29.3	13.5	11.4
Kansas	70.1	12.8	12.2

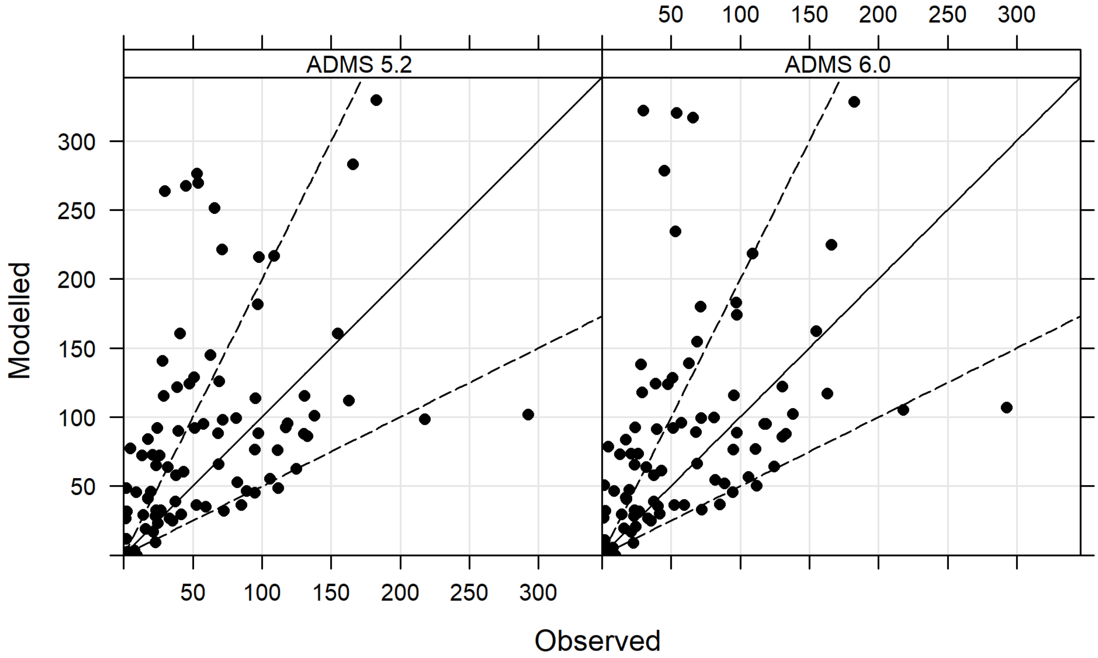
Table 4 – Dimensions of the buildings for both experimental sites.

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. 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 shows the scatter plot and quantile-quantile plot of results from both sites. Note that these quantile-quantile plots are linear; care should be exercised when comparing these plots with similar ones presented with logarithmic axes.



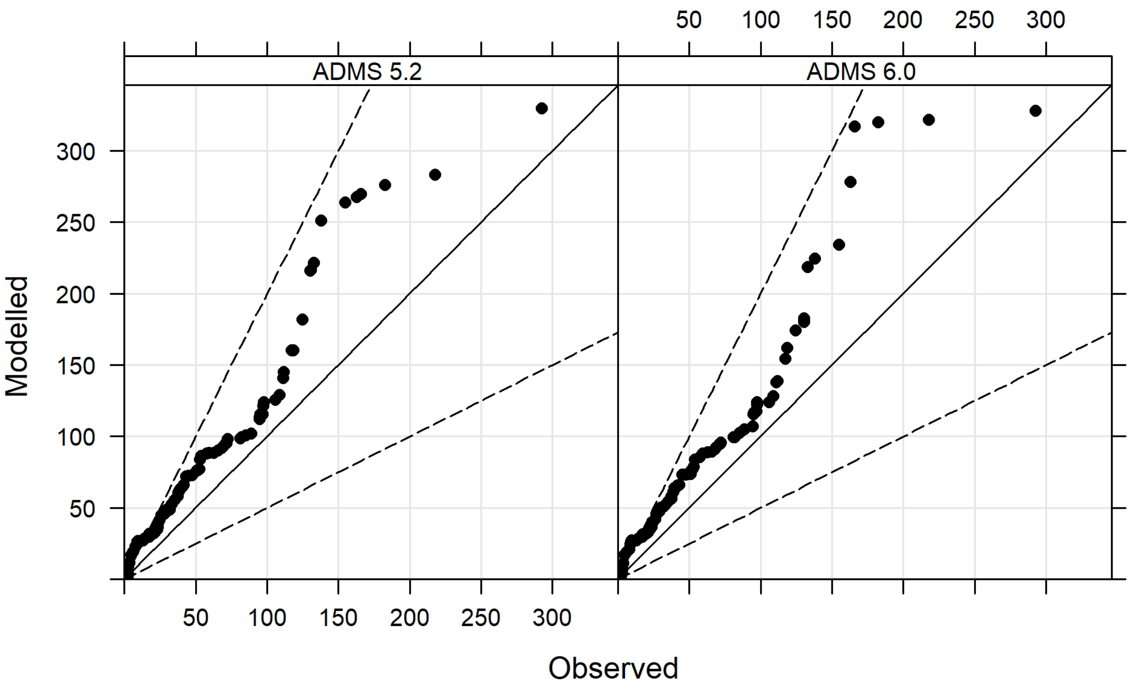


Figure 5 – Scatter plots and quantile-quantile plots of ADMS results against observed data (ug/m³).

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). **Table5** shows the statistical results for all runs from both sites.

Data	Mean	Sigma	Bias	NMSE	Cor	Fa2	Fb	Fs
Observed	58.66	54.09	0.00	0.00	1.000	1.000	0.000	0.000
ADMS 5.2	84.59	74.65	25.93	1.14	0.437	0.462	0.362	0.319
ADMS 6.0	84.20	76.24	25.54	1.20	0.418	0.495	0.358	0.340

Table 5 – Statistics for both sites.

4 Discussion

The scatter and quantile-quantile plots shown in Section 3.1, and the statistics averaged over all sites in Section 3.2 (**Table5**) indicate that ADMS over-predicts the observed concentrations. The correlation between modelled and observed values is reasonable (>0.4).

The differences between ADMS 5.2 and ADMS 6.0 are generally small. Over both sites, the mean concentration, bias, Fa2 and Fb statistics are slightly better with ADMS 6.0, but the other statistics (standard deviation, NMES, correlation and Fs) are slightly worse. There has been a change to the meteorological processor, in which the solar elevation angle is calculated at the middle of the hour rather than the end of it, which is having some effect in daylight hours. The ground-level plume emanating from recirculation region is now also 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; this is also affecting concentrations slightly. The development relating to how plumes that directly impact a building are modelled is unlikely to have any effect in this study given the large initial plume rise from sources that are already close to or above the height of the buildings.

5 References

[1] Engineering Science, 1980: *Field Validation of Atmospheric Dispersion Models for Natural Gas Compression Stations*. Report No. PR-133, prepared for the American Gas Association.

[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.