A COMPARISON OF RESULTS FROM ADMS AND AERMOD WITH MEASURED DATA

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INTRODUCTION

Ambient air quality around coal-fired power stations has been measured for many years as part of the UK electricity generators' Joint Environmental Programme (JEP). More recently (since 2002), air quality around the power stations has been managed via Air Quality Strategy (AQS) Management Plans which include requirements for air quality monitoring and plume dispersion modelling. The model currently used by the electricity generating companies is version 3.1 of ADMS. Environment Agency (EA) studies often use AERMOD, the plume dispersion model developed by the US EPA, in addition to ADMS.

In this study, the hourly results from two versions of ADMS (3.1 and 3.3) and two versions of AERMOD (99351 and 04300) were compared with hourly air quality measurements around groups of power stations in Yorkshire and the Lower Trent Valley for 1998 and 1999. A further comparison was undertaken for the area around Ironbridge power station (2003 and 2004), where terrain effects require consideration.

METHODOLOGY

The locations of the power stations and air quality monitoring sites in the Yorkshire and Lower Trent Valley study areas are shown in Figures 1 and 2.

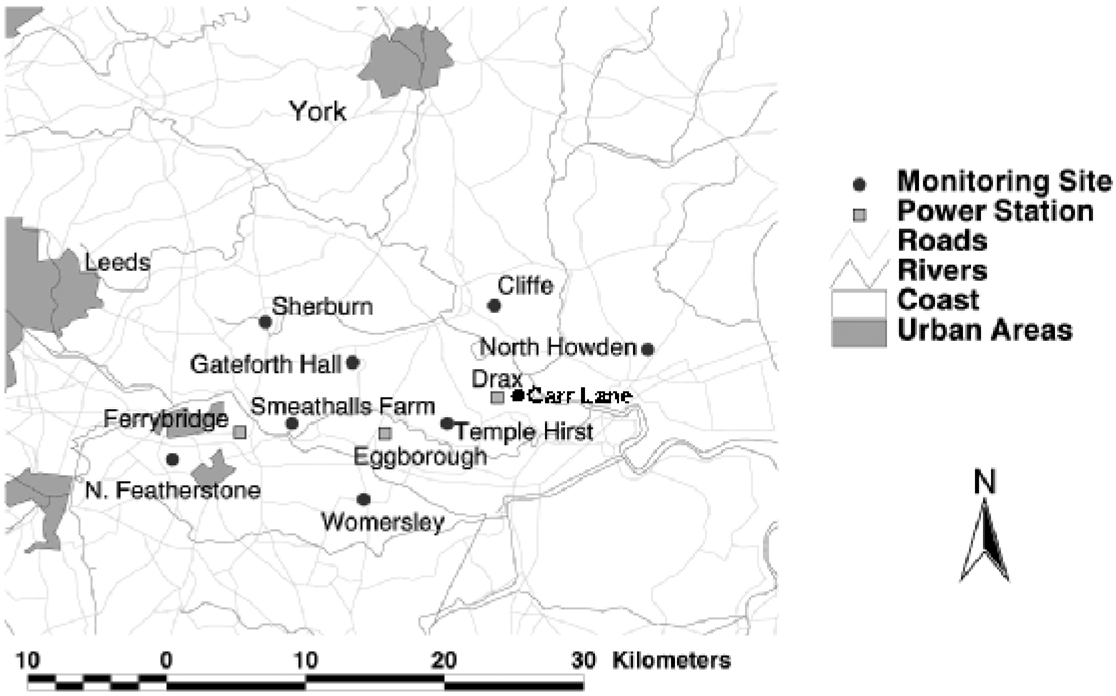

Fig. 1; Monitoring sites around the Yorkshire power stations

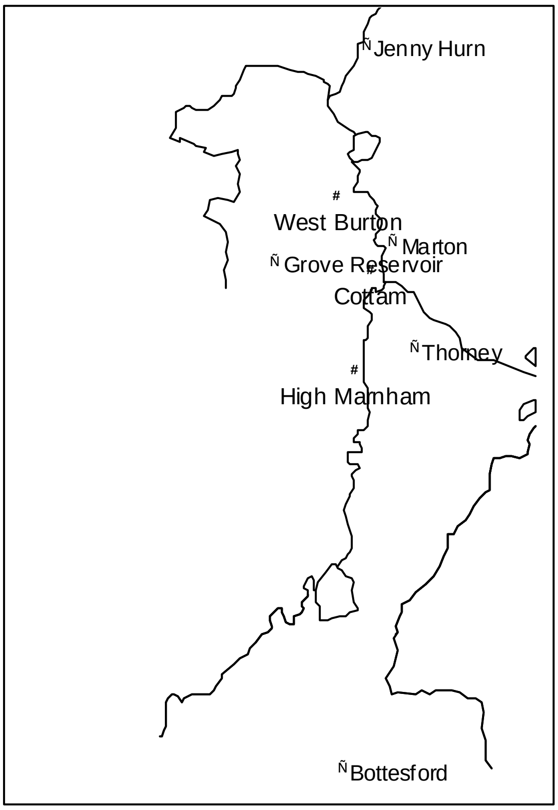

Fig. 2; Monitoring sites (crosses) around the Lower Trent Valley power stations (circles)

Only SO_2 concentrations were considered in this study, as coal-fired power stations usually make the dominant contribution to local concentrations of this species. Although the 99.9th percentile of 15 minute mean SO_2 concentrations is the most onerous of the AQS objectives for coal-fired power stations, the study focuses on predictions of 1 hour means, as AERMOD can calculate averages only for periods of 1 hour or greater.

Power stations were modelled as point sources without building or deposition effects, as these were considered insignificant. The hourly-varying volume flux was derived from the generation level for that hour, and hourly SO_2 emissions were determined based on monthly average fuel sulphur content. Concentrations were modelled at the locations of the relevant JEP air quality monitoring sites and also on regular output grids.

Before comparison with modelled data, the measured values were processed to remove the contribution of sources other than the local power stations. For each hour, the wind direction was used to identify which sites in the monitoring network were not downwind of any of the local power stations. "Background" concentrations were then estimated by averaging the measured concentrations from these sites, and the measured values were "corrected" by subtracting the averaged background value from the measured value.

AERMOD (99351) and AERMOD (04300) were both run using the Trinity Consultants interface software, Breeze AERMOD GIS Pro version 5.1.0 and Breeze AERMET Pro version 4.1.0. The US regulatory version of the model, AERMOD (04300) was run by selecting the PRIME algorithms; AERMOD (99351) was run from the same interface by not selecting PRIME.

RESULTS

Most results from both ADMS 3.3 and AERMOD (04300) – the most recent versions of these models at the time of the study - agreed with measured 1 hour SO_2 concentration statistics to within a factor of two, as shown in Figures 3 and 4 for the Yorkshire and Lower Trent Valley monitoring sites respectively. The following eight percentiles of 1 hour means were included in the comparison: 100th, 99.95th, 99.9th, 99.73rd, 99th, 98th, 97th and 96th.

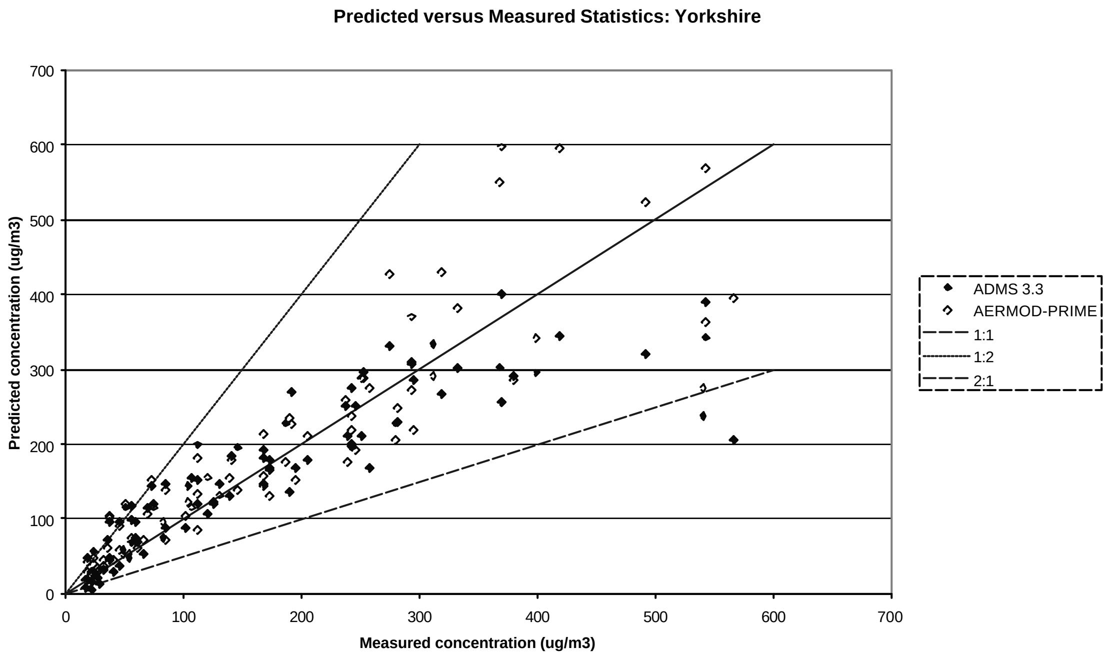

Fig. 3; Predicted percentiles of 1 hour mean SO_2 concentrations at all Yorkshire monitoring sites plotted as function of measured values

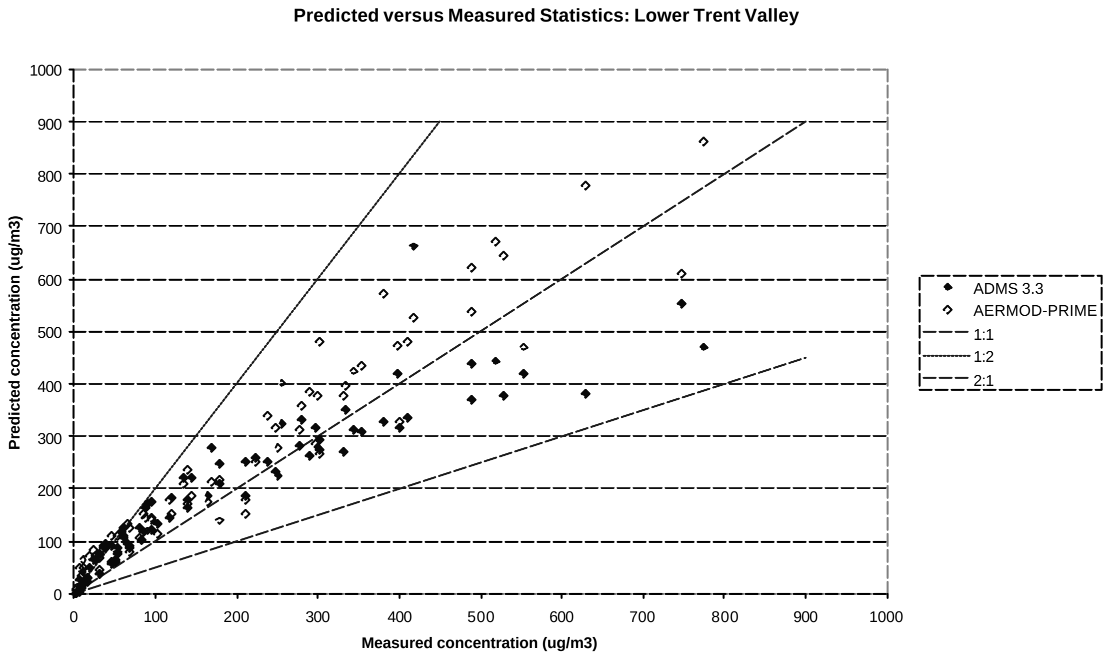

Fig. 4; Predicted percentiles of 1 hour mean SO_2 concentrations at all Lower Trent Valley monitoring sites plotted as function of measured values

In all three study areas, both models showed a tendency to over-predict values for 1 hour concentrations at the lower percentiles, typically up to about the 99th percentile. In flat terrain (Yorkshire and Lower Trent Valley), AERMOD tended to over-estimate the very highest 1 hour concentrations, whereas ADMS tended to under-estimate these values. Around Ironbridge (including terrain effects), both models tended to under-predict the 1 hour concentrations above about the 99.73rd percentile.

If predictions of the 99.9th percentiles of 1 hour means can be taken as an indicator of model performance relevant to the 15 minute mean AQS objective, the results suggest that both ADMS and AERMOD perform satisfactorily as, over the whole dataset for Yorkshire and the Lower Trent Valley, the model estimates of the 99.9th percentiles of hourly means are not significantly different from the measured concentrations at the 95% confidence level (the 95% confidence intervals for the modelled/measured gradients for the 99.9th percentiles are 0.93±0.08 and 1.05±0.10 for ADMS 3.3 and AERMOD (04300) respectively). Figure 5 exemplifies the generally good agreement between hour-by-hour SO_2 measurements and ADMS 3.1 predictions.

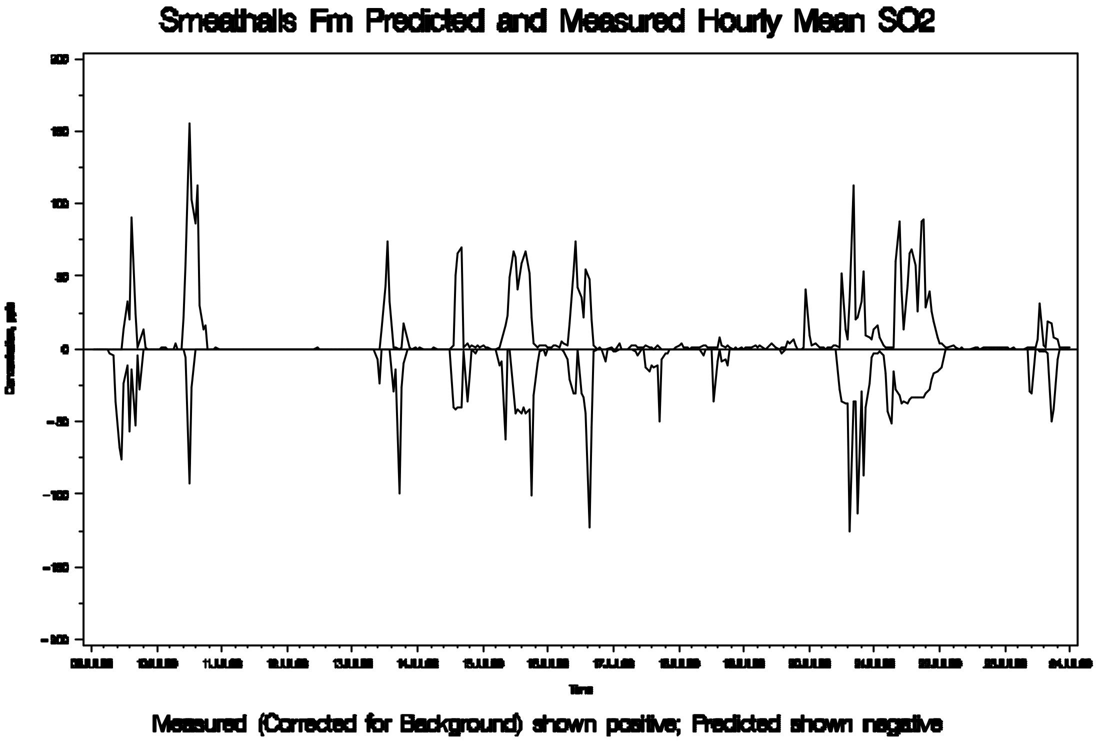

Fig. 5; Comparison of measured hourly mean SO_2 concentrations with ADMS 3.1 predictions at Smeathalls Farm, Yorkshire in July 1999

When comparing model predictions for the points of maximum impact on the modelled receptor grids, it was found that the results from ADMS 3.3 were almost the same as those from ADMS 3.1 (within 5%) for all of the concentration statistics considered. The only exception was in the Ironbridge study area, where the maximum 1 hour mean SO_2 concentrations predicted by ADMS 3.1 were about 15% higher than those predicted by ADMS 3.3.

The maximum 1 hour mean SO_2 concentrations predicted by AERMOD (99351) were always greater than the corresponding values predicted by AERMOD (04300), which were generally greater than the corresponding values predicted by ADMS. Again, the exception was in the Ironbridge study area, where the maximum 1 hour mean SO_2 concentration predicted by ADMS 3.1 in 2003 was greater than that predicted by AERMOD (04300) by about 15%.

DISCUSSION

The differences in results from AERMOD and ADMS are partly due to differences in meteorological pre-processing. A comparison of the boundary layer heights estimated for the 1998 Yorkshire study is shown in Figure 6. In this example (using the Trinity Consultants interface software), about 70% of the AERMET (04300) values are more than twice the ADMS 3.3 estimates and about 20% are more than three times. In both cases, the meteorological input data were those from Leeds Weather Centre.

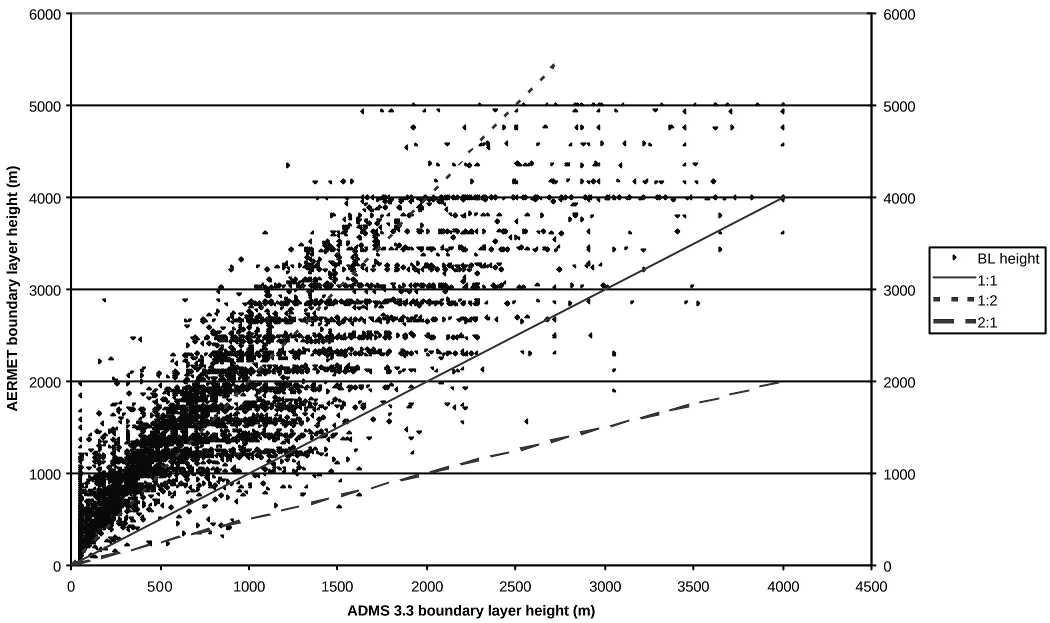

Fig. 6; Comparison of boundary layer heights estimated by ADMS 3.3 and AERMET (04300) for meteorological data used in 1998 Yorkshire study

As a result of these differences, the models may give very different results for low boundary layer conditions, as the trapping of a plume within a low boundary layer is very sensitive to the depth of the boundary layer relative to the height of the pollutant release.

With respect to differences in results from different model versions, the differences in maximum 1 hour SO_2 concentration results from the two versions of AERMOD are thought to arise from the inclusion of plume meander in AERMOD (04300). The differences in results from ADMS 3.1 and 3.3 in the Ironbridge study area are probably due to modified plume rise algorithms in ADMS 3.3 in very stable conditions when terrain effects are included.

CONCLUSIONS

Most results from both ADMS 3.3 and AERMOD (04300) agreed with measured 1 hour SO_2 concentration statistics to within a factor of two, indicating that both models are fit-for-purpose. Further studies would be required to examine the reasons for the differences between modelled and measured results in more detail, and to understand the differences between the output from the AERMOD and ADMS meteorological pre-processors.

ACKNOWLEDGEMENTS
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