An Intercomparison of the AERMOD, ADMS and ISC Dispersion Models for Regulatory Applications

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1. Introduction.

This work was commissioned by the UK Environment Agency to assess the AERMOD model for regulatory purposes in the UK and its performance in relation to the other advance dispersion model, ADMS. Until the appearance of AERMOD, recent UK regulatory practice had been mainly based on ADMS and the use of a second major advanced model would raise regulatory problems if these two models performed differently. The study had three main objectives. Firstly to review past intercomparison studies of these advanced dispersion models in relation to the older Pasquill/Gifford types of model. Secondly, to develop a protocol for model assessment which could be used in this assessment and which would provide a consistent framework for future assessment of models for regulatory purposes; the protocol and its background was described at HARMO6 (Hall et al(1999)). Thirdly, to compare the performance of AERMOD with ADMS and the older Pasquill/Gifford models and assess its performance for use in regulation. This work is now published by the Agency (Hall et al(2000a,b)). A brief description of it and some examples of the results are given here. The study compared the relative behaviour of the ISC, AERMOD and ADMS models, covering basic rates of dispersion, large plume rise, plume interaction with the top of the boundary layer, building downwash, annual calculations (the usual form of regulatory assessment), surface roughness and terrain. The models' treatments of terrain are described separately by Dunkerley et al(2001).

2. Review of Previous studies

The review of previous studies (Hall et al(2000a)) considered all papers up to the HARMO6 meeting. It identified over 120 papers related to the three models, their performance and matters related to intercomparison studies. However, of these only ten studies were found directly comparing either ADMS and AERMOD with each other or with the older models, of which only four involved systematic comparisons of well defined dispersion situations on a parametric basis. Some critical differences between the models were apparent from this work. However, the range of situations studied was limited and several important situations receive little attention, for example the effects of building entrainment and terrain. Little attention was given to variant versions of models issued over time and any differences between them. A critical feature of inter-comparisons appeared to be the handling of meteorological data inputs to the models, especially in the relationship between Monin Obukhov length scale based inputs and Pasquill/Gifford stability categories.

2. Present Study.

The present intercomparison used four single representative boundary layer conditions, of neutral (high and low wind speed), stable and unstable boundary layers, taken from a single years hourly meteorological data (from Lyneham, UK, in 1995). The same year's data was also used to compare annual calculations by the models.

Figure 1 shows a bar chart of ratios of maximum concentration between AERMOD/ISC and AERMOD/ADMS for unobstructed plume discharges at two heights, with and without plume rise. Figure 2 shows example calculations of plume centreline concentrations in three boundary layer states for a 150m high discharge.

The three models also treated building downwash differently. AERMOD and ISC calculate only a far field dispersion pattern, away from the separation region close to the building. ADMS partitions the plume between entrained and unentrained fractions, which are then summed. Some results of this behaviour are shown in Figure 3, which shows plume centreline concentrations at the ground for a 40m height discharge with, in turn, the unaffected plume, 25m and 35m high buildings and a 25m building with the source at the ground.

Results of some annual calculations are shown in Figure 4. The annual average and 98%ile contour maps are shown. The contours for specific concentrations vary significantly in both shape and area.

4. Sensitivity to Meteorological data

It became apparent during the course of the study that the advanced models, AERMOD and ADMS generally showed a greater sensitivity to changes in atmospheric conditions than the ISC model and that this produced significant differences between predictions of both the maximum concentration and its distance from the source. It was also apparent from the initial selection of single boundary layer states that the model's meteorological pre-processors often calculated markedly different boundary layer states from the same raw data input. Figure 5 shows a comparison between values of the Monin-Obukhov length scale and the boundary layer height calculated by AERMOD and ADMS. AERMOD persistently calculated deeper boundary layers than ADMS and the models often produced quite variable estimates of the Monin-Obukhov length scale. The effect of this was tested by feeding the same boundary layer states into AERMOD and ADMS, which significantly altered their modelled concentrations. Overall the differences reduced.

5. Discussion and Conclusions

A broad indication of the differences between the models was obtained from a count of the ratios of maximum concentrations obtained in the intercomparison. In these, about 28% of the ADMS and AERMOD maximum concentrations differed by more than a factor of two; with 15% of the ADMS/AERMOD ratios being high (>2) and 13 % low (<0.5). Of the ISC/AERMOD ratios, 35% were high (>2) and 3% low (<0.5). The majority of the differences between AERMOD and ADMS and ISC exceeded 20%. A simple summary of the results would be that, overall, ADMS produced maximum concentrations that were a little higher than AERMOD and that ISC produced maximum concentrations that were more generally higher than AERMOD. However the differences in many individual cases were quite large by regulatory standards. It also proved difficult to see any consistent patterns in the differences as the advanced models reacted to a multiplicity of input parameters in complex ways that were hard to distinguish.

A critical feature of the differences in model performance appears to originate in their meteorological pre-processors. These produced markedly different estimates of boundary layer depth for all three models and of the Monin-Obukhov length scale for ADMS and AERMOD. In a brief test in which the two pre-processor outputs were input to one of the models for an annual calculation, significant changes in the calculated concentrations resulted.

Despite these problems, the advanced models ADMS and AERMOD provide significant advantages over older models particularly in their treatment of the boundary layer and of complex terrain. However, the study demonstrated that the new generation models are still in a state of development and are sensitive to meteorological data processing methods.

6. References.

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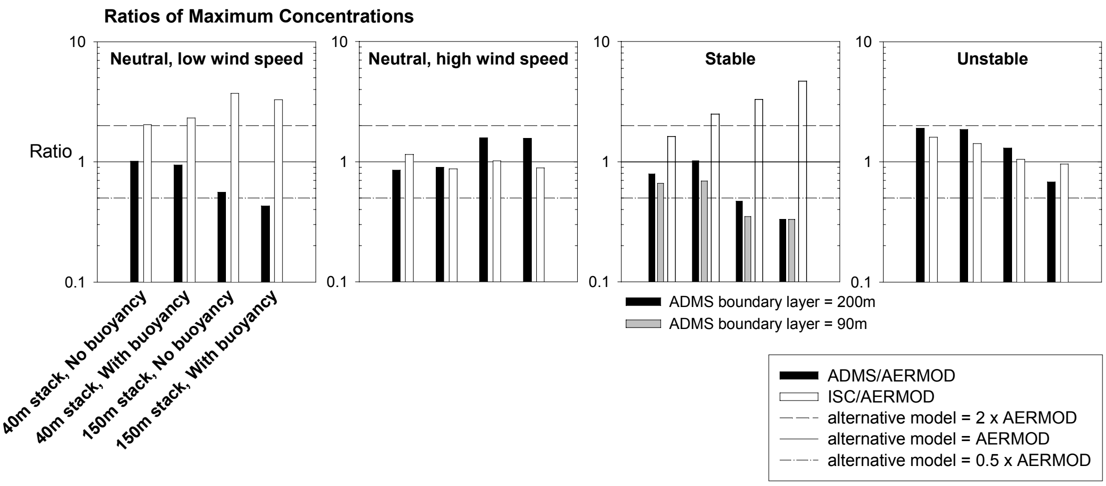

Figure 1. Basic dispersion rates for single conditions. Bar charts of maximum concentration. Ratios of values relative to AERMOD.

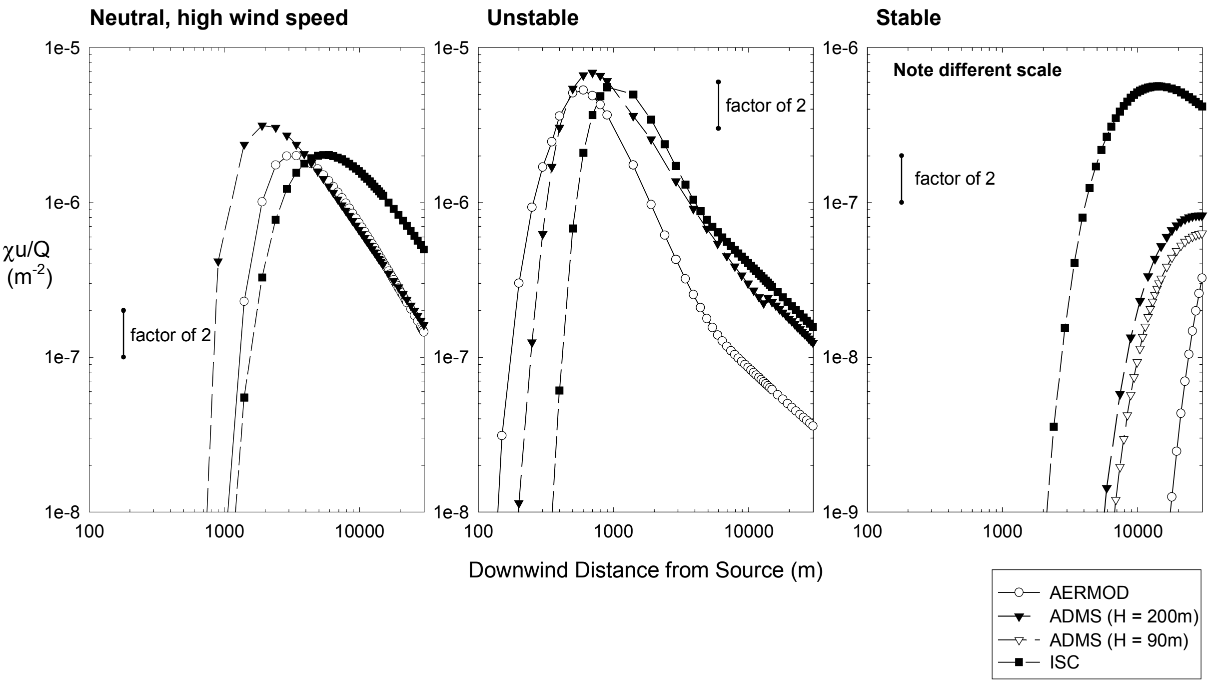

Figure 2. Basic dispersion rates for single boundary layer conditions. Normalised ground level plume centreline concentrations. 150m stack discharge, no buoyancy.

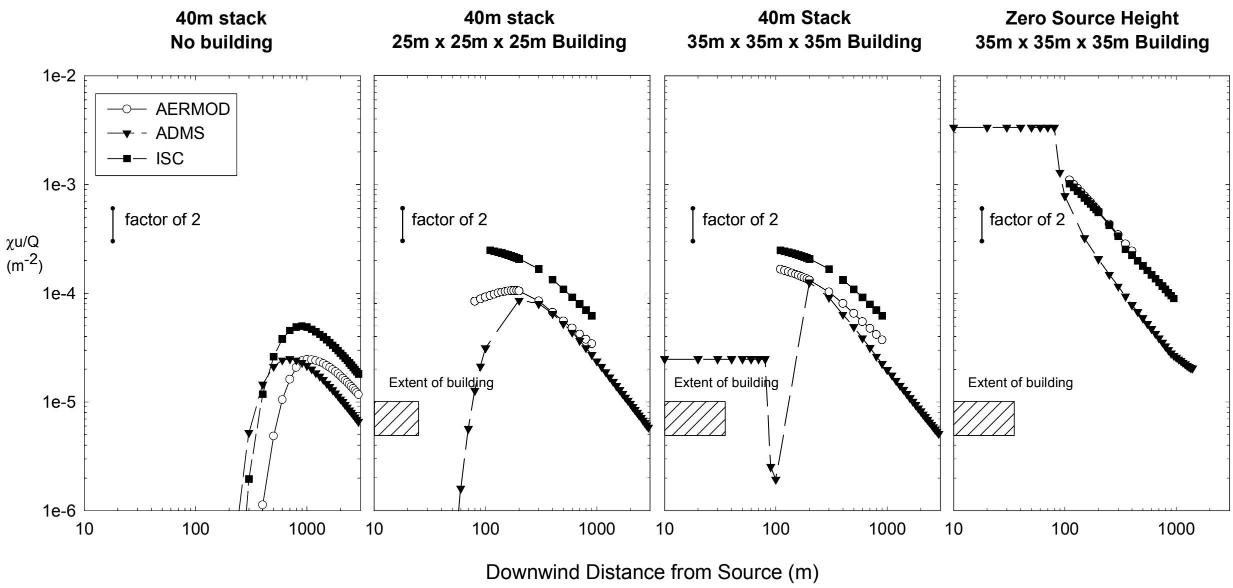

Figure 3. Effects of building entrainment for single neutral boundary layer conditions. Normalised ground level plume centreline concentrations. Neutral stability, 3.6m s^{-1} windspeed.

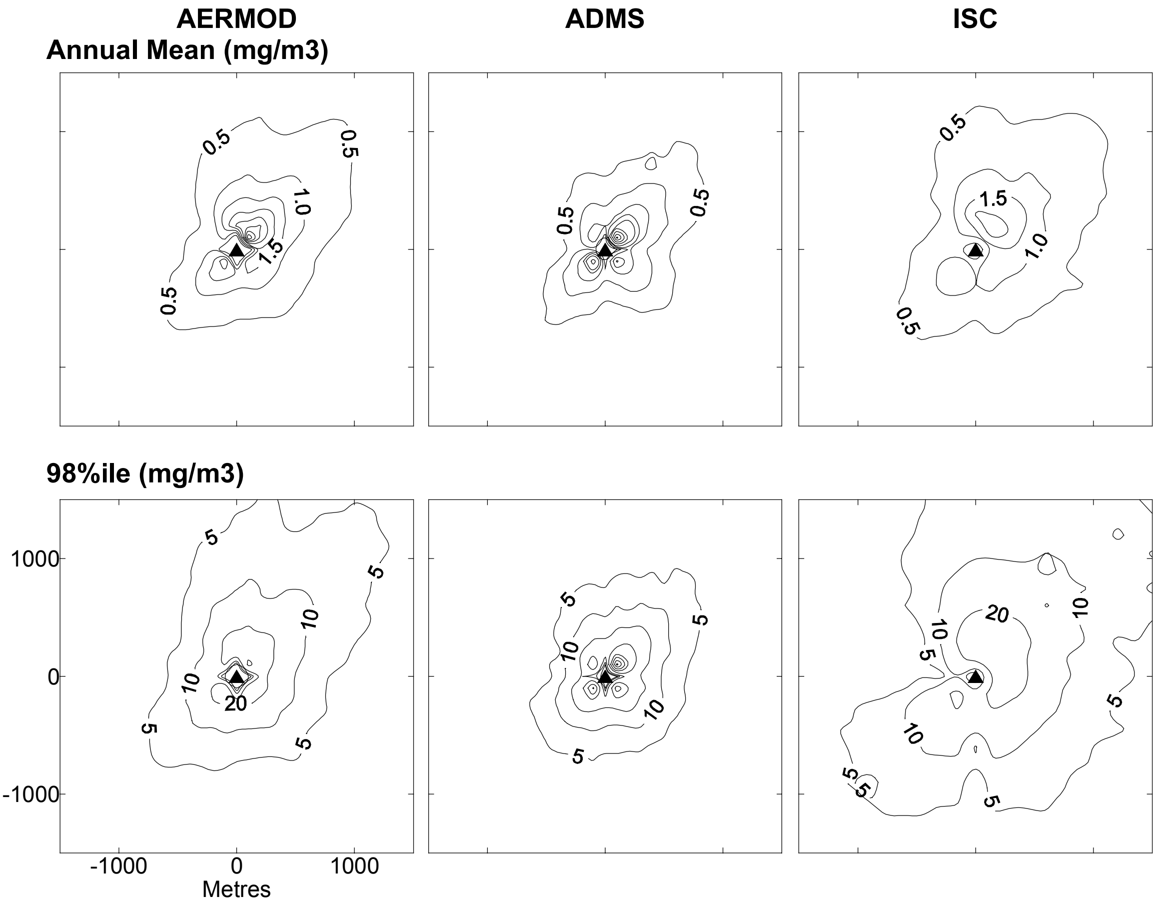

Figure4 . Annual statistics: ground level concentration patterns. 40m stack discharge with 35m cubical building, no buoyancy. For an emissionof 1000g s^{-1}.

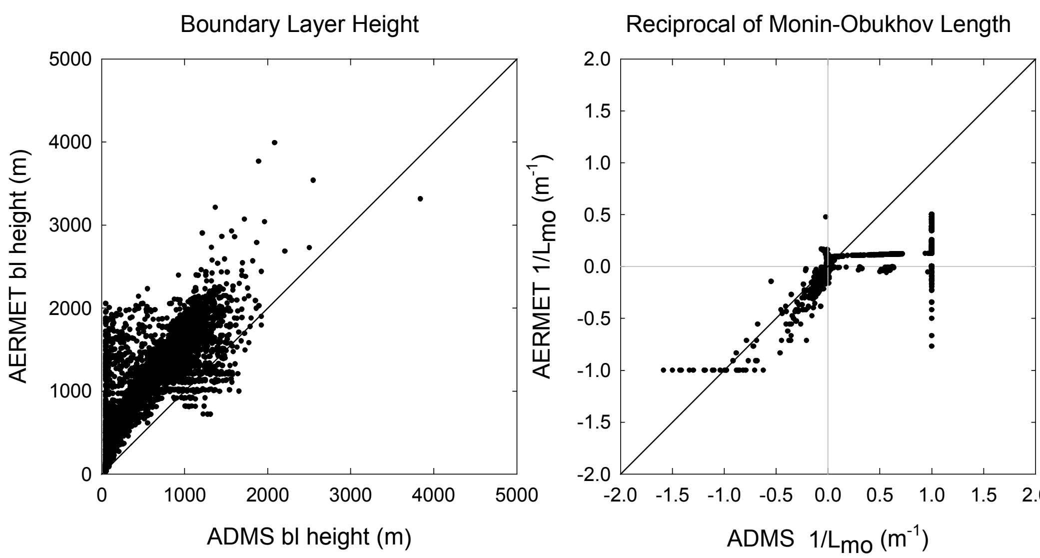

Figure 5. Comparison of AERMOD (AERMET) and ADMS meteorological pre-processor outputs for Lyneham, 1995.