15th January, 2001

Comments on Model Inter-Comparison Reports

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1. Introduction

1.1 The document is a technical response by those closely involved in the development of the ADMS model to two reports commissioned by the Environment Agency:

A Review of Dispersion Model Inter-comparison Studies using ISC, R91, Aermod and ADMS
D.J. Hall*, A.M. Spanton*, F. Dunkerley**(4), M. Bennett** and R.F. Griffiths**, Technical Report P353, September 2000.

An Inter-Comparison of the Aermod, ADMS and ISC Dispersion Models for Regulatory Applications
D.J. Hall*, A.M. Spanton*, F. Dunkerley**(1), M. Bennett** and R.F. Griffiths**
Technical Report P362, October 2000.

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1.2 Report P353 reviews model inter-comparison studies concerning ADMS and AERMOD and Report P362 describes a protocol for carrying out such studies and then reports an inter-comparison between the two models using the proposed protocol. Model developers were not invited to comment on the reports before publication which, although an understandable decision, makes our task more difficult as there are both fundamental issues and matters of detail to handle. Here we concentrate on the former, with the more important of the latter consigned to an appendix. Our intention is to contribute positively to the debate by clarifying certain technical issues and (via the Appendix) suggest matters that might be treated differently in revised versions of the reports, should such revision be requested.

1.3 The status and role of older models, such as (ISC and R91) is discussed. Whilst such methods might still be used for screening purposes there seems little reason to recommend this if there are no substantial differences in cost, or operational complexity in using more advanced models. Furthermore, many studies (e.g. those presented at the international series of Harmonisation Workshops) show that “new generation" models exhibit improved performance both in their range of applicability and in direct comparisons of performance measures. The older models may appear more stable but this is basically a reflection of their limitations, in that significant development based on improved understanding of the underlying physics and leading to wider capabilities required a new basis. The change from Pasquill classes to Monin-Obukhov length scale for determining stability is an example of a fundamental change, needed so that realistic account of the variation in boundary layer properties with height could be included. However, many modelling concepts are similar (e.g. the reflected Gaussian plume) so the idea of a clean distinction between new and old is a little artificial.

1.4 The reports imply there is less consensus between the new models than between the older models, and that more consensus would be desirable. This may or may not be the case, but we would point out that there is little value (except regulatory consistency) in a consensus which is inappropriate. The older models are actually less consistent than is sometimes assumed. For example, our paper from the Manno Harmonisation Workshop[5] shows differences in peak ground level concentration between an R91 model and ISC which are as large as a factor of 6 on occasion. Maes et al[6] (from the Mol Harmonisation Workshop) show significant differences between a range of Pasquill type models. They show different models giving different frequency distributions of Pasquill stability classes. Similarly, Farmer[7] compared four schemes for predicting Pasquill stability (all derived from work of Pasquill and/or Smith) and found large differences in the frequency distribution of the classes. R-91 gives two methods of calculating boundary depth, a nomogram for daytime conditions and a table of "typical values" which can be applied to any conditions, and it is quite easy to find cases where the two approaches differ by more than a factor of 2.

1.5 Regarding protocols for examining model performance, we agree that the goal of obtaining an understanding of model differences through a 'limited number' of dispersion calculations, which can be 'assessed by direct comparison without further recourse to complex analysis', is a worthy one. However we doubt that it is readily attainable, either because the 'number' may prove large or that a range of protocols would be required to cover the range of interest and applications of users. Modern dispersion modelling involves many degrees of freedom (especially when plume rise, buildings, complex terrain etc. are included) and we are not convinced that a small number of cases serves adequately to compare models. There are many expert scientists in this subject area (e.g. Hanna, Olesen, Britter) who could make valuable contributions to the debate and we hope that comments will be sought from a wide

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[5] D J. Carruthers, C.A. McHugh , A.G. Robins, B.M. Davies, D. J. Thomson, M.R.. Montgomery, "The UK Atmospheric Dispersion Modelling System: Comparisons with data from Kincaid, Lillestrøm and Copenhagen," Proceedings of the Workshop on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Manno, Switzerland, 1993,published by the European Commission.

[6] G. Maes, G. Cosemans, J. Kretzschmar, L. Janssen and J. Van Tongerloo, "Comparison of six Gaussian dispersion models used for regulatory purposes in different countries of the EU," Intl. J. Environment and Pollution, Vol 5, Nos. 4-6, 1995

[7] Met Office Internal Note SITN 37, 1984

range of individuals and organisations before protocols are “laid down” and that the protocols will not be ‘set in stone’ in a way which is a barrier to future innovation.

1.6 The reports concentrate on inter-comparisons and in doing so fail to bring out the substantial information on model performance available in other works (e.g. from evaluation studies for individual models), though a bibliography of such work is included in P353. We realise that the objectives of the two reports were confined to inter-comparisons but we believe this has limited their value since a reliable picture of model performance only begins to emerge once a large number of evaluation and like studies has been analysed. Further, performance itself is problem dependent.

1.7 Model assessment is a difficult area where many individuals and organisations have a useful contribution to make. While we believe that independent parties have a valuable role to play, we disagree with the suggestion that useful validation and comparison work cannot be done by model developers, users and regulatory authorities. In this field much of the scientific expertise lies with these organisations. What matters about work done for publication is that it should be transparent and sufficiently prescribed so as to be repeatable.

2. ADMS Development

2.1 ADMS has been developed by three organisations, CERC, the Meteorological Office and National Power (subsequently the University of Surrey) and its development has been determined and reviewed in detail by sponsors who have supported parts of the development. These include the Environment Agency (formerly HMIP), HSE, National Power, PowerGen, TXU (Eastern Generation), NRPB, MAFF, ICI, AstraZeneca, Nuclear Electric, Westlakes (formerly BNFL), AWE and Magnox. ADMS development and application is also discussed openly at regular User Group meetings.

2.2 Report P353 reviews comparisons between ISC, R-91, AERMOD and ADMS 1, 2 and 3 (the prefix ‘UK’ in UK-ADMS has not been used since version 1). We understand the desire to include the three versions of ADMS, because of the widespread interest in ADMS and because the main aim of the reports is to review and develop approaches to comparing models and experiences with earlier models may of course be useful for this. However, each version of ADMS was a substantial improvement on the preceding versions and there is a danger of confusing readers over the performance of the current model, ADMS 3. Additionally, some of the earlier studies with ADMS 1 and 2 (notably, Jones et al, 1995) led to considerable subsequent discussions and ultimately (and appropriately) to model developments. This is not brought out in the reports.

2.3 The full, updated and technically reviewed specification for ADMS 3 has been available from the CERC website (www.cerc.co.uk) since April 2000. Input for ADMS validation studies is available from CERC on request. Users can attend regularly held training courses, where many examples are discussed along with the basic science of the model, and (as noted above) attend regular User Group meetings. CERC operates a help desk for users’ operational inquiries which are usually responded to within 24 hours. Scientific questions may also be addressed to the other developers outside CERC - they are likely to be willing and able to provide appropriate answers but are under no obligation to do so.

2.4 ADMS has developed and expanded considerably since its first release, in response to changing regulatory demands, expanding user requirements and to improve model performance. We regard this as a positive aspect of the ADMS project. The balance between improving models and achieving stability and familiarity with their application in the user community is a difficult issue. However the emphasis on innovation and improvement in the ADMS project seems appropriate to us. In our view this has made ADMS 3 the most advanced short range regulatory type dispersion model world-wide, as is testified by the range of features included as standard and its performance statistics in comparison to measurements.

2.5 The model evaluation study performed by the American Petroleum Institute (API) was a completely independent study, although model developers were invited to comment on draft reports to avoid errors in the final reports. The study compared model calculations with observations from five field data collection campaigns. Two tables from this study are presented in Report P353 and are reproduced below.

Table 6 of P353. Hanna et al (1999b) summary scores of model performance

	ISC3	**ADMS**	**AERMOD**
Best	5	19	6
Middle	2	5	11
Worst	17	0	7
Best plus Middle	7	24	17

Table 7 of P353. Hanna et al (1999b) median performance measures for all the field data comparisons

	ISC3	**ADMS**	**AERMOD**
$MaxC_p/MaxC_0$	6.7	0.80	0.77
Geometric Mean	0.7	1.22	1.70
Geometric Variance	7.7	2.40	2.90
Fraction within x2	0.33	0.53	0.46

2.6 Table 6 shows summary scores for overall model performance and Table 7 presents average statistics where a value of 1 would represent a perfect result. Although it is true to say, as stated in Report P353, "… that no model in the study was consistently good or bad and that all the models had a creditable performance for at least some of the data-sets", we contend that the important conclusion is that both tables show ADMS has the best performance and ISC3 the worst. Distinctions between the performance of ADMS and AERMOD are less certain as we must be careful in deducing too much from a limited set of data. In fact as a consequence of the API study, and the fact that ADMS treats the impact of buildings, complex terrain and deposition in a self-consistent manner, **the API have recommended that ADMS be adopted as a regulatory model in the USA**.

3. AERMOD

3.1 We believe that there is potential for the reader to misunderstand the status of AERMOD, due to frequent inferences that the model is a US-EPA regulatory model. In fact, it was developed by the AERMIC Committee for the US-EPA but remains unapproved by the US-EPA and may not be used for regulatory applications in the USA except where satisfactory local validation is undertaken, the same condition that applies to use of ADMS in the US. Likewise, the building effects model referred to is called PRIME, not EPA PRIME. It was commissioned by the US Electrical Power Research Institute and has not been accepted for regulatory purposes. The status of AERMOD is unlikely to change in the near-future following recent debate in the USA. This focussed on the lack of certain desired model features (such as deposition etc.), the absence of an advanced model for building effects (such as PRIME) and reservations concerning the complex terrain module.

4. Meteorology

4.1 We wish to clarify the ideas about stability raised in the reports and which are fundamental to the difference between models like ADMS and earlier Pasquill models. The Monin-Obukhov/boundary layer scaling used in ADMS (and AERMOD) distinguishes between effects of stability when Pasquill Stability categories are unable to do so; e.g. behaviour of the boundary layer may appear near neutral near the surface, but perhaps convective higher up – ADMS and AERMOD recognise this whereas R-91 and ISC do not. In the reports, a boundary layer is taken as neutral in ADMS and AERMOD when h/L_{MO} is small (i.e. when thermal effects are negligible everywhere in the boundary layer) and in R91 when the stability category is D (i.e. when $1/L_{MO}$ is small and when the thermal effects are negligible near the ground).

4.2 Problems involved with the specification of boundary layer properties are discussed in the reports. We believe there are three separate issues to discuss. The first concerns estimating boundary layer parameters like h and L_{MO}, where the problems mainly arise in estimating long wave radiation, surface evaporation and ground heat flux, rather than because of lack of boundary layer equilibrium (as suggested in the reports), although the latter does also contribute. The second issue concerns the importance of thermal effects at different heights in the boundary layer (e.g. as characterised by z/L_{MO} or $\sigma_w/\sigma_{w\ neutral}$). This is not generally a problem in models such as ADMS and AERMOD which, unlike ISC and R-91, account for such effects provided the boundary layer is not too far from equilibrium. The third issue is departures from equilibrium which are a general complication. However, departures from equilibrium are not the main reason why ISC and R-91 cannot consider the changing structure of the boundary layer with height.

4.3 The comparisons of the different met pre-processors are of interest. In our view the differences are not surprising and reflect real uncertainties in predicting surface heat flux and boundary layer depth. Clearly it would be desirable to reduce the uncertainties, but we believe (i) that the differences are often not as serious as might at first be thought and (ii) that older models such as R91 and ISC suffer just as much from this issue. For near surface sources the dispersion depends on turbulence intensities near the ground and these are often weakly dependent on L_{MO} and h (e.g. in convective conditions they depend only on $1/L_{MO}^{1/3}$ and $h^{1/3}$). We are not saying here that stability is unimportant, only that plotting $1/L_{MO}$ rather than $1/L_{MO}^{1/3}$ exaggerates the scatter. For strongly buoyant sources however boundary layer depth can be very important (e.g. in questions such as: does the plume leave the boundary layer or not?) and there is no getting away from the fact that it would be desirable to reduce uncertainty. In fact, uncertainty between met-processors exists for all models, whether or not the processors are integral parts of the model.

5. Plume Rise

5.1 The ADMS plume rise model is treated in the reports as something unusual and is usually described as being a complex, recursive procedure. In fact, such methods are not at all unusual; e.g. they are widely used in models developed for process industry safety assessment, such as the Shell HG-System. ADMS uses an integral model to calculate plume trajectories because this is an essential feature in any dispersion model that is to be applied to complex flow conditions, such as in building wakes or complex terrain (e.g. PRIME uses a similar integral model), or is to be used with generalised initial conditions (e.g. arbitrary emission direction). Briggs models that are used in many earlier dispersion models are limiting solutions of the integral model and they and the integral model give very similar results where Briggs models are applicable. Actually, there is more than one formulae which could be called a Briggs formula, e.g. the formula for the rise of a bent-over plume with downwind distance in a neutral atmosphere and the formula for final rise in a stable atmosphere.

5.2 Plume rise was studied within the HMIP funded ADMS validation study (Carruthers et al[8]). In some cases both the Briggs equation and the ADMS model agreed closely, but in some cases the study showed quite dissimilar behaviour with the ADMS plume rise model showing far superior performance than the Briggs model. An example is that shown in Figure 8 of P353, which refers to the most comprehensive and reliable data-set in the Carruthers et al study.

5.3 The interaction between a rising plume and the inversion at the top of the unstable boundary layer is important but has proved a difficult feature for all model developers to handle. This has been as much the case for ADMS as for other models (e.g. HPDM, Hanna et al[9]). In all cases, inversion penetration by a rising plume is a progressive process, responding to continuing plume rise and spread in the external flow, gravitational settling and so on. The ADMS plume rise module allows for partial penetration of the inversion with the fraction increasing or decreasing with fetch. The penetration fraction is available as output.

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[8] Carruthers D. J., Edmunds H. A., Bennett M., Woods P. T., Milton M. J. T., Robinson R., Underwood B. Y. and Franklyn C. J. 1997. "Validation of the ADMS Dispersion Model and Assessment of its Performance Relative to R-91 and ISC using Archived LIDAR Data" *Int. J. Environment and Pollution* Vol 8, Nos. 3-6

[9] Hanna S. R. & Paine R. J. 1989 "Hybrid Plume Dispersion Model (HPDM) development and evaluation." *J. Applied Meteorology* 28, pp206-224

6. Building Effects

6.1 Building effects are notoriously complex and no model, even a CFD procedure, can claim great predictive accuracy. ADMS represents the input building or group of buildings by an effective, block-shaped building normal to the approach flow, though including an alignment parameter, $0=\theta=45°$, describing the orientation of the input main building to the wind in the description. This is an important parameter as it is subsequently used to determine streamline deflections over the effective building and its near-wake. Two limiting conditions are modelled: with $\theta=0$ there is no deflection and with $\theta=45°$ a maximum deflection; in general the deflection is taken to be proportional to $\theta/45$. The limits can be thought of as the likely bounds to building effects. Streamline deflection decreases with increasing plume height, becoming zero at the edge of the building effects region. Further streamline deflection arises in the main wake region as a consequence of the decay of the velocity deficit in the wake. These are important features of the model which were not fully examined in the reports as only normally aligned buildings were considered. The decision to confine building effects studies in this way restricts the usefulness of conclusions drawn.

6.2 Plumes may be partially entrained into the near-wake, a behaviour predicted by the ADMS near-wake model. This is equally true of roof level emissions, where entrainment proves to depend upon building geometry and orientation, source location, discharge properties and the ambient conditions. This near-wake model naturally leads to a two-plume structure downwind, one plume emanating from the near-wake and the other the remaining fraction of the elevated plume, which may continue to rise due to the remaining part of the initial buoyancy. These concepts are also to be found in PRIME. The statement in Report P362 that "all the models treat near field building entrainment in quite primitive ways" may well be true but it does not acknowledge the achievements that have been made and might be interpreted as construing that all models treat entrainment at a similar basic level, which is clearly incorrect. For example, ISC and AERMOD do not model near field entrainment at all and, unlike ADMS, adopt modelling in the main-wake that is independent of the stack location relative to the building.

6.3 Discussion in Report P362 includes the comment that "none of the models was effective at estimating near-field building plume downwash and entrainment." This must certainly be true of ISC and AERMOD as they do not model the building near field at all. However, there is no evidence to substantiate the assertion for ADMS, or the subsequent statement that the two plume approach is "unreliable". Indeed, ADMS evaluation studies (e.g. Robins and McHugh, 1999) show otherwise, though it seems clear that the expected accuracy of building effects models must always be less than that of the underlying dispersion model. A similar comment can be based on the evaluation work reported for PRIME.

6.4 Unexpected (at the time of development) model applications can prove valuable in identifying areas where improvement is needed. The use of ADMS with tall, thin structures is a case in point. Deficiencies identified by Harvey (1998) led to some development of the algorithms which were subsequently incorporated in ADMS 3. Recent modelling work on a tall, thin, cement works building (presented to the Environment Agency in November 2000) shows that ADMS predictions agree with the available wind tunnel data to reasonable accuracy whereas AERMOD shows no effect of such a building on dispersion.

6.5 A further issue that was first highlighted in the NRPB report of Jones et al (1995) was the appearance of discontinuities in the ground level concentration field at the boundary between the near and main wakes. Subsequent work identified that the problem lay in the use of a box model in the near-wake and a plume model in the main wake and algorithm revisions reduced the occurrence of the discontinuities but did not eliminate them. A similar situation arises in PRIME, where a patching region has been introduced to ensure a smooth transition. The two plume model may lead to the prediction of a second concentration maximum in the main wake region, but is not the cause of the discontinuity at the near-wake boundary

7. Complex Terrain

7.1 Appendix 1 of Report P362 discusses some of the differences between the treatment of complex terrain in ADMS and AERMOD. This notes that ADMS calculates a perturbed mean and turbulent velocity field over the terrain using the linear wind flow model FLOWSTAR, without adding that a separate plume impingement model is included in ADMS 3 to handle cases of strongly stable flow. A separate treatment is also included for releases within a region of recirculating flow. With FLOWSTAR, plume rise and spread relative to the flow streamlines are predicted as a function of downwind distance and used with a Gaussian plume model to predict concentrations. The procedures used in AERMOD are next described in the Appendix. No terrain wind fields are calculated and the model bases concentration predictions on weighted averages from terrain following and horizontal plumes. The Appendix notes that plume impact on the hillside is assumed even under convective meteorological conditions, that the model does not discriminate between terrain upstream and downstream of the source, and that plumes impact on a hill or spread around it even if the source is on the lee side of the hill, all of which, if correct, are unphysical. These are major differences between the models.

7.2 Results of a systematic study on the effect of topography on dispersion were presented to the US EPA 7th Modelling Conference by D. J. Carruthers in June 2000 and are available from the CERC and US EPA websites. Results from a further study were presented to the Environment Agency in November 2000. These studies investigated the effect of a source at different locations (including in the lee of a hill, on top of a hill, as well as the case considered in P362, namely upwind of a hill) and clearly shows the benefits of the ADMS approach by comparison with wind tunnel data. We believe that any protocol for model comparison which attempts to address complex terrain should include a wider range of cases than the source upwind of a hill case considered in Report P362.

7.3 The ADMS and AERMOD approaches to terrain grids are so different that it is difficult to undertake meaningful comparisons. The ADMS terrain input grid may contain up to 5000 points that do not have to be regularly spaced and the user can, for instance, add some spot heights to improve the definition of the terrain. The calculation grid is used within the program and the user can select a grid of 16x16, 32x32 or 64x64 points. The output grid is not tied to either of these grids. In contrast, AERMOD requires the receptor locations to be the same as the locations at which terrain height information is given.

7.4 Report P353 (page 19, first paragraph and page 23, last paragraph) notes that "Hanna et al use the Lovett field data against which AERMOD has been validated and against which it was by far the best performer." However, careful examination of Table 5 in P353 suggests a completely different conclusion as ADMS is superior in two of the statistics presented, AERMOD in one. Further discussion of complex terrain modelling is included in the presentation by D. J. Carruthers to the US EPA 7th Modelling Conference (details above).

8. Final Comment

We hope that this document contributes to the clarification of the material contained in the Environment Agency reports and that we have helped to show why, in our view, ADMS is currently the most advanced short range regulatory type dispersion model world-wide, as is testified by the range of features included as standard and its performance statistics in comparison to measurements.

Appendix - Detailed Comments

Report P353

Page 3, Jones et al study
The Jones et al report generated much correspondence with the ADMS developers at the time and the conclusions of Jones et al, which referred to ADMS 1, are not valid for ADMS 3.

Page 4, last paragraph, entrainment
See Sections 6.1, 6.2.

Page 5, paragraph 3, Bugg study
The Environment Agency is aware that PLUMES had some serious errors and was not a faithful representation of R-91. Some details of ALMANAC justify inclusion to contrast it with the R91 model. ALMANAC was first developed by David Moore and was very advanced for its time. In some respects, R91 took a step backwards in comparison. ALMANAC used Moore's plume rise model, specified dispersion as a function of plume height and used different upward and downward diffusivities and hence plume spreads. Briggs plume rise might later have been included as an option to replace Moore's plume rise.

Pages 7-10, Section 2.3, Discussion of plume rise
See Section 5.

Page 9, end of para 1
See Section 4.

Page 11, Harvey study
See Section 6.4.

Page 12, paragraph 1, Harvey study
ADMS 3 does not assume constant concentrations over discrete arcs. In ADMS 2.2 the assumption of constant concentrations over discrete arcs was only used for the calculation of long term averages for single point sources using statistically analysed met data.

Page 13-16, API study
See Sections 2.5, 2.6, 7.4.

Page 16 EPA PRIME
See Sections 3.1 and 6.3.

Page 19, Hill study
The Hill et al study used effective stack heights determined from wind tunnel experiments as input to ADMS so the results are not straightforward to interpret in terms of model comparison. The point was that, once the effective height is known, then under near-neutral conditions there was little difference between ADMS and R91 predictions.

Page 20-21 Discussion of McHugh et al paper and fractional bias
The second paragraph of page 20 correctly states that the MAC procedure and MVK notation refer to the same method, but in all that follows these are taken to be two different methods. MAC (MVK) should in fact be contrasted with NCC, so in Table 9 the columns headed MAC should be headed NCC. However, the values in the column currently headed MAC in Table 9, are not straightforward values of fractional bias, but are pooled, weighted values of absolute fractional bias. They should not be

compared with the straightforward values of fractional bias from MVK as they are not the same parameter at all.

Page 21, Table 9, first paragraph

For completeness it should perhaps be noted in Table 9 that the Indianapolis data are quality 2 and 3 and the Prairie Grass data are all qualities.

Page 22, middle

The very rapid contact of airborne plume with the ground in unstable conditions is of course entirely consistent with observation, going back to Willis and Deardorff's original work in 1976[10]).

Page 23, boundary layers, end of paragraph 2

See Sections 4.1, 4.2.

Page 23, third paragraph, R91

The R91 building effects model only applies to emissions that are fully entrained, although the R157 report gives guidance for other cases.

Page 23, last paragraph and page 19, first paragraph, Lovett data.

See Section 7.4.

Page 24, second paragraph, model development

See Sections 2.2, 2.4.

Report P 362

Page i, paragraph3, summary

It would be useful to also consider a somewhat lower stack such as is typical of many industrial releases

Page ii, recommendation (1)

See Section 1.3.

Page ii, recommendation (2)

See Sections 1.4 and 2.4.

Page iii, recommendation (4)

See Section 1.7.

Page 2, paragraph 4, protocols

See Section 1.5.

Page 2, 3 and elsewhere, status of AERMOD and PRIME

See Section 3.

Page 4, Section 3.1, first paragraph, Page 5, paragraph 2 and elsewhere, protocols

See Sections 1.5, 1.6.

Page 4 , model features

Given the importance of NO_2 for regulatory applications in the UK it would be appropriate to include chemistry modules as being of major importance. This is an area where ISC and AERMOD have not been developed because NO_2 standards are not an issue in the USA, whereas ADMS is specifically designed to consider UK and EU air quality standards. Equally, a case could be argued for reducing the list further to maximise the value that might be achieved through a more detailed comparison of a limited range of features.

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[10] Willis G. E. & Deardorff J. W. "A Laboratory Model of Diffusion Into the Convective Planetary Boundary Layer", Quarterly. J. Royal Met. Soc. (1976) 102, pp427-445

Page 10 and elsewhere, ADMS plume rise model
See Sections 5.1,5.2
Page 12, end Section 3.6, building effects
See Section 6.1.
Page 13, paragraph 3, ADMS complex terrain model
Full details of the calculation methodology were sent to one of the authors at the beginning of April 2000, 8 months before the report was published.
Pages 14-15, from bottom of page 14 to end of section 3.8, terrain grids
See Section 7.3.
Page 21, paragraph 2, inversion penetration
See Section 5.3.
Page 25, paragraphs 3-5, building models
The ISC and AERMOD algorithm modifies the plume spreads and calling it a downwash correction, as is often done, is confusing.
The report states that "details of the whole building entrainment model are not fully explained in the CERC technical documents." The technical specification is very detailed and whilst there might be omitted detail we are not aware of any significant omissions. We will of course act upon notification of any significant omission.
Page 25, paragraphs 3-5, two plume model
See Sections 6.1, 6.2.
Page 26, top, discontinuities
See Section 6.5.
Page 27, paragraph 2, contour plots
The reader may get the impression that the difference in smoothness of contours between the annual average and high percentile concentrations is due to the plotting package. The plots faithfully represent the given data and the differences can mostly be explained physically. The annual average is the average of a large number of met cases, but the top percentiles depend on just a few met cases, and these met cases that produce the highest concentrations may not occur for all wind directions, leading to the apparent spikiness.
Page 27, paragraph 3, building effects
The report states that Figure 21 shows "the models generating their highest concentrations nearer the source on the diagonal of the array grid… the effect appeared most marked with the ADMS and AERMOD models". The changing cross-wind dimension of the building does indeed contribute but with ADMS the plume deflection is greatest for the diagonal case and this is likely to be the major factor. In fact ISC does not predict the highest values of the 100th percentile on the diagonal of the receptor grid, so the ISC behaviour is opposite to that observed in experiments.
See also Section 6.1.
Page 34, paragraph 2, terrain and convective conditions
The limited effect of terrain on concentrations under convective conditions is a real physical effect.
Page 36, first paragraph, FLOWSTAR
The ADMS wind field perturbations are not just a function of local terrain gradient and the highest concentrations do not always, or even usually, occur where the terrain is steepest.

Page 36, fifth paragraph and subsequently, ADMS plumes in complex terrain

The plume centre line in ADMS is displaced laterally and vertically by the flow over complex terrain. The lateral concentration profile is symmetrical about the displaced streamline.

Page 37, second paragraph, plume widths over terrain

It would be more correct to say that, in this case, the ADMS plume width is not *significantly* affected by the terrain. A simple plot of lateral spread with and without terrain would show that there is some effect.

Page 39, paragraph 3, concentrations over complex terrain

Maxima being closer to the stack does not suggest the dominance of unstable conditions. The meteorological conditions are, of course, the same as in the flat terrain case and the position of the maxima for the convective cases is likely to be least affected by the presence of terrain. Maxima closer to the stack are more likely to result from the convergence of the streamlines approaching the hill. This causes the maximum ground level concentrations to be nearer to the stack for stacks upstream of and lower that the height of the hill.

Page 41, Section 4.7.6, terrain grids

See Section 7.3.

Page 42-46, Section 4.8 and Page 9 Table 2, stability cases

The data in the reports in fact suggest that the four basic stability cases chosen may not be enough to give a fully representative behaviour of the models. For example, all four cases chosen have AERMOD as more neutral than ADMS (as judged by the value of Monin-Obukhov length) whereas the scatter plot of $1/L_{MO}$ values, Figure 38, suggests that in many (and possibly most – there are too many points on the plot to see the density of points) ADMS is more neutral.

Page 42-46, Section 4.8, meteorological pre-processors

See Section 4.3.

Page 42, para 4, boundary layer depths

The paragraph refers to the effect of changing the boundary layer depth "for all the dispersion calculations". The changes to the boundary layer height were: AERMOD 188m to 200m, ADMS 90m to 200m, and 130m to 200m, ISC no change. Therefore, as the only significant changes made were to the ADMS model input it is not surprising that only ADMS showed a change in output.

Page 43, middle, near-field building effects

See Section 6.3.

Page 47. Specifications

The full, updated and technically reviewed technical specification for ADMS 3 has been available from the CERC website (www.cerc.co.uk), since April 2000. Some validation results of AERMOD and ISC are presented on the US-EPA website, however it is not possible to download the input data. Input for ADMS validation studies is available on request.

Page 48, first and second paragraphs

The longer run times for ADMS with terrain effects reflect the greater sophistication and complexity of the calculation.

Page 49, middle paragraph beginning, output

In the ADMS contour plotting utility the terrain contours are generated automatically.

Page 50-51, Section 5.5, washout

No justification or discussion is given for the statement that "None of the washout models is satisfactory for the short ranges at which the models normally operate".

The same holds for the brief discussion in the following paragraph of concentration fluctuations. In the final paragraph, the statement concerning ADMS model options that "Some cause difficulty in practical application" is not substantiated. While, as noted in sec 5.6, no dispersion model is perfect, it would have been useful to have explained what the authors' concerns were.

Page 50, paragraph 3, deposition

ADMS can make use of a user provided deposition velocity if it's available, but does not require one as it can be calculated from the met condition and gas type, or, particle diameter and density.

Page 51, Section 5.6, response of Suppliers

CERC operates a help desk for users' operational inquiries which are usually responded to within 24 hours. The authors' detailed technical enquiry referred to in sec 5.6 fell outside the realm of a "helpdesk" enquiry. A full response was provided at the beginning of April 2000, 8 months before the report was published. Scientific questions may also be addressed to the other developers outside CERC, they are likely to be able to provide appropriate answers but are under no obligation to do so.

Page 53-54, model consensus

See Section 1.4.

Report P362, Appendix 1, complex terrain

See Section 7.

Report P362, Appendix 2, Page 110, paragraph 2, inversion penetration

See Section 5.3.