1.13 A DISPERSION MODEL INTERCOMPARISON ARCHIVE

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INTRODUCTION

The main application of dispersion models is in the regulatory process, where they are commonly used both as predictive tools and for supplying detailed interpolation maps between monitoring data. In general, the regulatory limits for most pollutants are set with a precision that cannot be matched by the predictive accuracy of dispersion models. The main reasons for this are the approximate nature of all useable dispersion models, significant levels of uncertainty in the validation data against which the models are calibrated, the uncertain state of the atmosphere for which calculations are usually made and other uncertainties in the model's data inputs.

Despite the heroic efforts (the only way to describe a field experiment) of many very competent groups to collect good data for model validation purposes, the inevitable variability of such measurements makes precise model validation impracticable. As a result it is perfectly feasible for two models for similar applications to use such data to achieve similar levels of statistical reliability in validation studies and yet to produce significant differences in calculation for identical applications.

Such differences between models in similar applications are of great regulatory significance and it is necessary for these differences to be appreciated by both regulators and commercial users. This is especially so where (as in the UK) there is no prescription of the use of a particular model, as long as the model is considered fit for its application. This matter became more critical in the UK in recent years, during a period when regulatory dispersion modelling studies were passing from using earlier models based on Pasquill/Gifford stability criteria (ISC and R91) to the more advanced models using Monin-Obukhov stability parameters. Furthermore, two advanced models were becoming available, the UK's ADMS model (Carruthers et al(1994)) and the USEPA's AERMOD model (Cimorelli et al (1998)).

In the interests of determining the differences in behaviour between these models in regulatory applications, the UK Environment Agency commissioned a model intercomparison study (Hall et al(2000a,b)). We have reported briefly on this study previously at the HARMO6 (Hall et al(1999)) and HARMO7 (Hall et al(2001), Dunkerley et al(2001)) meetings. The study posed three main questions,

1) Given that regulatory dispersion studies may use any of these models, are there likely to be significant differences between them (from a regulatory point of view) in predicting concentrations to be compared with the required air quality standards for the same application?

2) Is it possible to identify how these differences arise and to account for them in regulatory practice in some simple way?

3) Is there a simple test procedure (or protocol) which would reveal such differences between models? This will also have to satisfy a continuing need to deal with new models and versions of models as they appear, partly so that a historical perspective of the effects of dispersion model changes on regulatory practice can be seen.

The answer to the first question was, unhesitatingly, yes.

The answer to the second question was that it was only partially possible to do this. Many of the differences between model calculations did not follow consistent patterns and because of the relative internal complexity of the advanced models it was often difficult to see how specific differences between model calculations arose. However, it did appear that differences in the meteorological pre-processors of the respective models made a significant contribution to differences between the dispersion calculations.

In answer to the third question we devised a suitable test protocol. It has to be appreciated that its purpose was to reveal any significant differences between regulatory model calculations, not every nuance of their properties. Thus if two models compared using the protocol did not show major differences, it would be unlikely that using them for the same regulatory calculation would show any serious differences. We took the view that this should be done with the practicable minimum of calculations, both in the interests of economy and in being able to review relatively quickly any differences between the models being compared. It is very easy in this type of work to become lost in a mass of calculations which are not en masse very revealing, since it is often only a few critical results that are important to intercomparisons. Overall, the test protocol achieved its aims and it has been used subsequently by the Environment Agency's Air Quality Modelling and Assessment Unit for further model intercomparisons (AQMAU(2002)).

We also noted the importance of the test protocol remaining stable over time, so that the differences between existing models, new versions of existing models and new models could be assessed historically for their effects on regulatory decisions. In order for the test protocol to achieve these further aims and to promote its more widespread application, a full archive of the protocol test base was required for ready access and assimilation by any interested parties. This has now been done and a complete archive of the model intercomparison protocol is available. It is described below.

THE MODEL INTERCOMPARISON ARCHIVE.

The archive has been prepared in the interests of disseminating the test protocol as widely as possible and of encouraging its further use by any interested parties, so that standard intercomparisons can be continued and a historical perspective of dispersion model performance can be developed. It contains everything required to carry out further calculations with new models or revised versions of the ISC, ADMS or AERMOD models and there is sufficient information to provide input to any other model. It includes,

- Copies of the original Environment Agency intercomparison study reports and Technical summary.
- Input and output files for all the model calculations carried out in the study.

- The meteorological data sets needed for the calculations, in the formats provided both directly by the UK Meteorological Office and via Trinity Consultants.
- The terrain data files used in the study.
- Other papers relevant to the study.
- The ADMS model developer's (CERC) comments on the study (Carruthers et al(2000)) and the authors' reply (Hall et al(2003)), which includes a discussion of the use of dispersion models in regulatory practice.

The model assessment protocol included test cases using single weather conditions and using hourly annual weather data, the form in which regulatory assessments are usually made. They are described in more detail in the reports on the work and in our HARMO6 paper (Hall et al(1999). These were, briefly,

- Basic rates of plume dispersion in neutral, stable and unstable atmospheres for low and high stacks.
- Plume Rise.
- Large buoyant plume interaction with, and penetration of, the top of the boundary layer.
- Building entrainment.
- Effects of terrain on basic plume dispersion.
- Ground level concentration contours for a single year's hourly meteorological data.

The meteorological test conditions covered,

- Four boundary layer states, neutral strong wind (ca 10m s^{-1}) and neutral, stable and unstable light wind (ca 3m s^{-1}) for single shot calculations. The meteorological parameters, based on examples from site data, were fixed for these cases. The low wind speed case was used with three boundary layer depths to test large buoyant plume interaction with the top of the boundary layer.
- Two stack heights, low (40m) and high (150m) with zero and high (5MW and 100MW respectively) buoyancy discharges.
- Two building heights (attached to the lower stack) of 25m and 35m, of cubical and low, wide form. The relative heights of stack and building were designed to produce significant plume partitioning and wake entrainment in one case and significant plume downwash but no direct wake entrainment in the other.

The terrain test cases used a common terrain pattern (from the Dstl, Porton Down Range) scaled to provide,

- Three levels of gradient slope; normal, half and twice normal.
- Three levels of terrain stack height; equal to, greater and less than the stack height.
- Three distances from the stack to the steepest part of the terrain,

All model input and output files are clearly identified and tabulated. It proved essential to include the original model output files as, even in the few years elapsing since the original work, it has become difficult to repeat the original calculations due to changing model versions and operating systems.
The inclusion of the meteorological data set was considered a critical feature of the archive. This is normally only available at significant cost from its suppliers (the UK Meteorological Office and Trinity Consultants Inc, who also supply versions of the AERMOD and ISC

models used in the study). Recognising the value of the archive, both parties have generously permitted the inclusion of the two meteorological data sets (hourly data for Lyneham, in the UK, for the single year 1995) for further studies. Both meteorological data sets originally derive from the UK Meteorological Office; that provided by Trinity Consultants is obtained via the NCDC in Washington, which collects data worldwide. Because they are analysed differently (see Hall et al(1999) and Hall and Spanton(1999)), the meteorological data sets from the two parties (which can be used in any of the models) give different results in dispersion calculations.

ARCHIVE AVAILABILITY

Some parts of the archive can be accessed via the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) web site (see AQMAU(2002)). AQMAU will also supply copies of the archive on CD on request. The complete archive can also be downloaded through the HARMO web site (www.harmo.org/intercomparison/intro.asp). The authors will also provide the archive on CD on request.

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