Atmospheric Dispersion Modelling

Liaison Committee Report: ADMLC-R16

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INCLUDING

A review of methods used to assess the performance of atmospheric dispersion models

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PREFACE

In 1977 a meeting of representatives of government departments, utilities and research organisations was held to discuss methods of calculation of atmospheric dispersion for radioactive releases. Those present agreed on the need for a review of recent developments in atmospheric dispersion modelling, and a Working Group was formed. Those present at the meeting formed an informal Steering Committee that subsequently became the UK Atmospheric Dispersion Modelling Liaison Committee. That Committee operated for a number of years. Members of the Working Group worked voluntarily and produced a series of reports. A workshop on dispersion at low wind speeds was also held, but its proceedings were never published.

The Committee has been reorganised and has adopted terms of reference. The organisations represented on the Committee, and the most recent terms of reference adopted, are given in this report. The organisations represented on the Committee pay an annual subscription. The money thus raised is used to fund reviews on topics agreed by the Committee. The new arrangements came into place for the start of the 1995/96 financial year. This report describes the most recent activities of the Committee. These include a review of methods used to assess the performance of atmospheric dispersion models. The technical specification for the contract is given in this report, and a link to the contract report can be found on the ADMLC website. Previous studies funded by the Committee are described in its earlier reports.

The Committee intends to place further contracts in future years and would like to hear from those interested in tendering for such contracts. They should contact the secretariat:

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1 ORGANISATIONS REPRESENTED ON THE COMMITTEE

The organisations on the committee at the time of publication of this report are:

Atomic Weapons Establishment, Aldermaston (AWE)

Defence Science and Technology Laboratory (Dstl)

Environment Agency for England (EA)

Health and Safety Executive (HSE)

Met Office (MO)

Natural Resources Wales / Cyfoeth Naturiol Cymru (NRW)

Office for Nuclear Regulation (ONR)

United Kingdom Health Security Agency (UKHSA)

Scottish Environment Protection Agency (SEPA)

RISKAWARE

EDF

The present Chairman is Dr Simon Gant of the Health and Safety Executive and the Secretariat is provided by the UK Health Security Agency.

2 TERMS OF REFERENCE

The terms of reference of the committee are:

Areas of technical interest

1. ADMLC's main aim is to review current understanding of atmospheric dispersion and related phenomena for application primarily in authorisation or licensing of discharges to atmosphere resulting from industrial, commercial or institutional sites. ADMLC is primarily concerned with dispersion from a particular regulated site or from discrete sources and will not normally consider work in the following areas: traffic pollution, acid rain and ozone.
2. ADMLC is concerned both with releases under controlled conditions occurring at a constant rate over long periods, and with releases over shorter periods such as accidents or controlled situations where the release rate varies.
3. ADMLC is concerned with modelling dispersion at all scales, including on-site and within buildings.

Organisations and outputs

4. The Committee shall consist of representatives of Government Departments, Government Agencies and organisations with an interest in modelling dispersion of material for the situations identified above. Each organisation represented on the Committee shall pay an annual membership fee.
5. ADMLC believes that it can be most effective by limiting its membership to about 25 organisations. New organisations will only be admitted to membership of ADMLC if the majority of existing members agree to their membership.
6. ADMLC aims to review, collate, interpret and encourage research into applied dispersion modelling problems. It does not endorse particular brands or suppliers of commercial models. However, it is concerned to ensure that users for industrial applications are aware of what is available, how it can be applied to particular problems and of the uncertainties in the results.
7. The Committee will commission work on selected topics. These should be selected following discussion and provisional agreement at meetings of the Committee, followed by confirmation after the meeting. It will produce reports describing current knowledge on the topics. These may be reports from contractors chosen by the committee or may be based on the outcome of conferences or workshops organised on behalf of the committee. The money raised from membership fees will be used to fund contractors, organise workshops and report on their outcome, and any other matters which the Committee may decide.

3 WORK FUNDED DURING THE YEAR (TECHNICAL SPECIFICATION)

3.1 A review of methods used to assess the performance of atmospheric dispersion models

An important aspect of using atmospheric dispersion models is to understand how a model performs against measured data. Many commercially available models are validated using widely available datasets, applying various statistical metrics (e.g. correlation, Root Mean Square Error etc), and/or graphics (e.g. scatter, Q-Q plots, statistical distributions). It is important that the underlying model has sound physics and mathematics (see attached* 'Framework for Model Evaluation in HSE', Coldrick 2018; also RR1099), and it is imperative that model validation does not mis-represent the true performance of the model, by cherry-picking datasets to make a model look good, or by not considering the quality of the monitoring data being used. Validation carried out to a high standard can provide confidence that the model is suitable for use in other locations and is especially advantageous where monitoring data is unavailable.

However, it is important that when monitoring data is available, model users are able to test and verify the model performance for their specific project and understand the uncertainties (including both model inputs and inherent model uncertainties) in the specific case they are undertaking. For this study, we are assuming the model is based on sound science and has been verified and the focus should be on the validation stage of the HSE model evaluation framework.

Many factors may influence the type of model performance tests carried out such as model inter-comparison tests, model type (e.g. Numerical/Gaussian/CFD), the quality of monitoring data and how this data is used in the evaluation, environments (e.g. urban/rural), source types, monitoring methods or different averaging periods (e.g. short term v long term) and the type of datasets being compared (e.g.model v observations or model v model). In each case the performance tests required, or the acceptability criteria for 'good performance', may differ.

There are several published methods of quantifying model performance, including statistical metrics (Chang and Hanna (2004); Venekatram (2008); Liu et al (2011)) and downloadable tools (CERC Model Evaluation Toolkit, FAIRMODE tools, or the open-source R library 'OpenAir') which assess model performance, and which publish model acceptability criteria. It has been noted that these tools use different statistical metrics for assessing model performance, and that the published model 'acceptability criteria' can vary. Methodologies to interpret the data are constantly evolving, such as the analysis of sensors in an arc around a source (Hanna, Chang and Strimaitis (1993)).

ADMLC is interested in seeking tenders that will review the different published methods of comparing models against observed data. Observed data can include sources other than ground level monitors (e.g. satellites). We are not looking to develop new statistical metrics, or formalise an approach, however we are looking for the review to consider all the published methods, highlight the strengths and weaknesses that these methods offer (e.g. do different model evaluations lead to the same conclusion) and provide recommendations and guidance on when to use particular statistical tests.

Stage 1

The study should firstly include a literature review of how model performance is currently evaluated in commercially available packages (validation documents) and in research papers. This should include published model performance, or how a particular dataset has been used in different studies, across the range of different model types (e.g. Gaussian or numerical) and model backgrounds (e.g. commercially available, operational, research models and ensemble modelling systems). The performance metrics used in the evaluation studies should be evaluated. This should consider the combination of metrics used and how this can be used to diagnose problems or biases within a model. A single metric can be misrepresentative and misleading but can be very informative when placed alongside other metrics (graphical and numerical).

It is also important to consider the data requirements to support the calculation of different metrics, such as quality and quantity of the data (e.g. spatial distribution, sampling frequencies and uncertainties), and if the usefulness and robustness of the metrics can vary depending on the datasets used to verify a model.

Stage 2

Having identified performance metrics in the literature review, the performance metric should be assessed in further detail by outlining the advantages and disadvantages of using a particular method for different model types in case studies. These case studies should use datasets and model types in agreement with the Committee. The performance metrics considered should not necessarily be restricted to statistical values but should also include other approaches such as graphical analysis of the data or how the dataset is used in the analysis (e.g. would the outcome change if particular parts of a dataset were selected). This should consider how performance metrics may relate to long term (e.g. annual means) and short term (hourly values or percentiles) standards and, in particular, Air Quality Standards (e.g. 99.79th percentile of hourly mean).

Stage 3

The study should summarise the findings (identified in Stages 1 and 2) and provide recommendations of which model evaluation methods should be used for different situations (e.g. Gaussian/Numerical, Urban/Rural environment, Point source or non-point source, long or short term), guidance on using datasets for model evaluation and if any further work is needed on this topic.