Atmospheric Dispersion Modelling

Liaison Committee Report: ADMLC-R6

June 2011

INCLUDING

Reviewing Issues Associated with Modelling Atmospheric Dispersion in Changing Meteorological Conditions

Source Term Estimation and Event Reconstruction: A Survey

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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 terms of reference adopted, are given in this report. The organisations represented on the Committee pay a small annual subscription. The money thus raised is used to fund reviews on topics agreed by the Committee, and to support in part its secretariat, provided by Health Protection Agency (HPA). 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 included a review of issues associated with modelling atmospheric dispersion in changing meteorological conditions and a review of techniques for source term estimation and event reconstruction. The technical specifications for the contracts are given in this report, and the contract reports are attached as annexes to this report. 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 Secretary:

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1 ORGANISATIONS REPRESENTED ON THE COMMITTEE

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

AMEC

Atomic Weapons Establishment, Aldermaston

Defence Science and Technology Laboratory

Department for Environment Food and Rural Affairs (DEFRA)

Department of Energy and Climate Change (DECC)

Environment Agency

Food Standards Agency

Health and Safety Executive

- Hazardous Installations Directorate
- Office for Nuclear Regulation

Health Protection Agency

Home Office

Meteorological Office

Nuclear Department, HMS Sultan

Scottish Environment Protection Agency

Shell Global Solutions

The present Chairman is Dr Matthew Hort of the Met Office and the Secretariat is provided by the HPA.

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

3.1 Reviewing Issues Associated with Modelling Atmospheric Dispersion in Changing Meteorological Conditions

Many models of atmospheric dispersion assume steady state conditions, ie, that the atmospheric conditions remain constant during the travel of the released material to the point of interest, and in some cases also throughout the period over which material is released. ADMLC would like to identify those situations where these limitations are not appropriate and to this end wishes to commission a study to review the issues and priorities associated with modelling dispersion in changing met conditions. ADMLC wish the results of this review to be presented to ADMLC together with options for possible modelling studies to further explore the issues.

It is appreciated that met conditions may change temporally, spatially or as a combination of the two. The implications of these changes for atmospheric dispersion should be discussed, However, ADMLC is primarily concerned with temporal changes and to avoid this study becoming too wide and unfocussed it may be necessary to concentrate on this aspect only. Temporal changes in met conditions are those situations where the meteorology at a point on the dispersion path changes with time while the dispersing material is still passing that point. This change in conditions may be significant for some applications and therefore the dispersion of the plume cannot be adequately modelled using a single set of met data. As well as modelling the transport of the plume adequately consideration should be given to the sensitivity of the receptor point. For some receptors it may be necessary to predict air concentrations averaged over periods of less than an hour while for others annual average air concentrations may be sufficient.

A review of historical events where changes in meteorological conditions were significant should be included as input to the decision on whether changing meteorology is significant. One such example would be short-term rainfall events over UK uplands that coincided with the arrival of the radioactive plume from Chernobyl and lead to long-term implications for sheep farming.

The review should also consider the modelling application (eg, emergency response, emergency planning, air quality management and continuous annual discharges) and the endpoints to be calculated. What are the particular issues associated with the use of steady-state models for these applications? It is only worth discriminating between different met conditions if these differences mean that there will be significantly different consequences for the endpoints of interest.

For each application the use of non steady-state models should be considered and the potential benefits of using them discussed. Are suitable models and input data available? To what extent are data available to validate the models?

Suggestions for modelling exercises to demonstrate/test how the use of non steady-state models can improve predictions should be put forward for each application. It is possible that these exercises might also be used to demonstrate that steady-state models are appropriate for some applications.

In summary the project should:

- Identify the causes of changing met conditions, focussing mainly on temporal changes
- Discuss the implications of these changes for atmospheric dispersion
- Review historical events where changes in met were important to the outcome
- Discuss the requirements of dispersion modelling for various applications, ie, emergency response etc taking into account the endpoints of interest
- Discuss the issues associated with using steady-state models for these applications and prioritise in order of importance/greatest impact
- Discuss if suitable models and data (met, sources, validation data) are available for non steady-state modelling
- Discuss how modelling might be used to demonstrate that non steady-state models are better/no better for each application
- Interim presentation of progress
- Final presentation of findings and recommendations for modelling studies.

The report on this work is published as ADMLC/2010/1.

3.2 Source Term Estimation and Event Reconstruction: A Survey

Hazardous Chemical, Biological, Radiological and Nuclear (CBRN) releases can occur from either a deliberate attack or an accidental incident. Rapid detection, assessment and early response to CBRN releases could dramatically reduce the extent of human exposure, help mitigate the immediate disruption and minimize the cost of the subsequent clean up. To this end, by characterising the plume through time, either directly or via source term estimation and a dispersion model, prediction of the dispersion of the contaminant can be made.

For example, in the case of an accidental industrial release, hazard assessment via event reconstruction will identify likely release times and masses to enable accurate targeting of warnings to surrounding areas. Or alternatively, for a covert bioterror attack of an agent such as anthrax, source term estimation and

event reconstruction could help to inform the planning of public health mitigation strategies.

With particular interest in this application in the last few years, numerous methodologies have been developed for making inference about source term parameters from a wide range of data sources.

ADMLC is interested in seeking tenders to review the state-of-the-art for source term estimation and event reconstruction. It should be emphasised that the techniques of interest are those that can predict the source term from the subsequent pattern of dispersion in the environment. The main focus of the study should be a broad scope investigation of these different methods with clear benefits and drawbacks of each, together with the different contexts of use. It should be assumed that an estimate of the source term based on the processes that lead to its creation will not be possible due to a lack of information.

Generally, the mathematical methods applied to these problems include Bayesian, Markov Chain Monte Carlo (MCMC), four dimensional variational methods, adjoint assimilation, Kalman filter, statistical learning, eg, Genetic algorithm or simulated annealing and other heuristic schemes.

The particular method of preference will depend on the particular context in question. Considerations include the scale (large scale (eg, international) to local, small scale (eg, 10 km)), setting (industrial, homeland defence, military) and the particular parameters of interest (eg, location, time of release, mass, number of releases, probability distribution or point estimate, release rate, moving releases).

It is envisioned that there may be distinct methodologies for particular contexts and as such the review may be divided between these.

Further, specific methods may have dependencies upon a given dispersion model, so this information should not be overlooked. However, the limitations of a given dispersion model are not the focus of this survey.

Finally, the study should summarise its findings and advise on future work needed to develop this topic.

The report on this work is published as ADMLC/2011/1.