Atmospheric Dispersion Modelling

Liaison Committee Report: ADMLC-R15

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INCLUDING

Investigating the impact of applying different grid resolutions of NWP data in atmospheric dispersion modelling

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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 an 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 Public Health England (PHE). 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 an investigation of the impact of applying different grid resolutions of NWP data in atmospheric dispersion modelling. 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)

EDF Energy

Environment Agency for England (EA)

Environmental Protection Agency for Ireland (EPA)

Food Standards Agency (FSA)

Health and Safety Executive (HSE)

UK Health Security Agency (UKHSA)

UK Meteorological Office (MetOffice)

National Resources Wales (NRW)

Office for Nuclear Regulation (ONR)

RISKAWARE

Scottish Environment Protection Agency (SEPA)

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

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 Investigating the impact of applying different grid resolutions of NWP data in atmospheric dispersion modelling

ADMLC funded an investigation into the impact of applying different horizontal grid resolutions of NWP met data when modelling the atmospheric dispersion of material in different types of assessment scenario. Scenarios included regulatory modelling of impact assessments for EPR permitting and planning, and probabilistic accident consequence assessments e.g. in respect of radiological releases. The aim was to review the selected NWP models and provide recommendations on resolution of NWP met data to be used in these scenarios.

Meteorological (met) station sites may be too far from, and situated in differing topography to, the release location(s) and thus met station derived data may be unrepresentative. The quality and availability of numerical weather prediction (NWP) model data is continuously improving. As a result, NWP model data is becoming more widely used as input to air dispersion modelling for regulatory air quality impact assessments, and for probabilistic accident consequence assessments in respect of radiological releases.

The resolution of NWP model data has been improving with the advances in predictive algorithms and computing power. For example, Met Office Unified Model (UM) NWP data resolution was 60 km prior to 2004, then down to 12 km in 2004, 4 km in 2007 and 1.5 km in 2013. Currently, most environmental permit applications, and environmental agencies use the Met Office UM 1.5 km NWP met data when representative observational met data is not available. Some consultants provide other NWP model data with different resolutions, e.g., GFS NWP data has a resolution of about 13 km and achieved at 0.5 degree, WRF data has a resolution of 1 km and 4 km, and NEMS data has a resolution of < 4 km.

Different NWP modelling approaches and spatial resolutions result in different degrees of representativeness of NWP met data at a local level. The effect of terrain on air flow may be considered in an NWP model, depending on the scale of terrain and NWP model resolution. Since some atmospheric dispersion models, e.g. ADMS Flowstar, also explicitly consider the impact of terrain effects on air flow, there is concern that double counting of the terrain effect for a regulatory air dispersion modelling assessment may occur.

The ADMLC is interested in investigating the consequence of using different spatial resolution of NWP met data on model predictions of annual mean concentration and high percentile hourly concentrations for a regulatory assessment. Furthermore, the Committee wishes to investigate the consequence of using different spatial & temporal resolutions of NWP met data on model endpoints derived by way of probabilistic accident consequence assessments.

The aim of this project is to recommend optimal spatial (and where applicable, temporal) resolutions of NWP data currently available to be used in 1) regulatory air dispersion modelling and 2) probabilistic accident consequence assessments. This project should consider only archived or reanalysis (and not forecast) NWP met data. Application of WRF model and/or Met Office UM model data in this study would be preferred but it is recognised that this is dependent on the availability and access to data.

The investigation should include the following aspects.

1) The work should include an introduction to NWP models (including Met Office UM model, WFR, NEMS and GFS), and a review of their performance, in terms of their weather prediction accuracy, from published literature in the last ten years. Model grid resolution should be included in the introduction and review.

2) For one (or more) chosen NWP model(s), at three spatial resolution levels (i.e. 1-1.5 km, 4 km and 12 km), compare model endpoints derived for each of the hourly NWP met datasets for a range of receptor locations, over both flat and complex terrain conditions.

Comparison between NWP wind data and observed wind data should also be included with a view to see whether the application of more finely resolved NWP met data results in more representative dispersion modelling predictions. The NWP met data should be representative of the same location as the observed met station. It is known that information from a chosen observed met station may be reflected in the NWP data already but observed met modelling serves a purpose as a reference for NWP modelling with different resolutions.

3) For the regulatory atmospheric dispersion modelling investigation, carry out comparison studies for several chosen scenarios, i.e. typical intensive farming emission (simplifying to a close to ground level point source) and elevated point source emission. Both flat and complex terrain should be included. Three years NWP met data for each location should be used in the comparison studies.

These model comparison studies should include NWP met data at three different resolution levels as well as observed met data. Both long term (annual mean) and short term (100th and 98th percentile hourly average) model predictions should be included in the comparison. The modelling domain can be divided into eight equal wind directions, and model predictions for each wind direction at an appropriate distance should be compared and analysed. This distance can be determined by using the distance to the maximum predicted concentration location for each case (i.e., annual mean, 100th and 98th percentile) over the whole modelling domain.

Consideration of ADMS and AERMOD would be preferred, but the models to be applied can be agreed in consultation with the Committee.

4) The work should also examine whether there is potential for double counting of the impact of terrain. A model domain of 1 km x 1 km from the release location for intensive farming emissions and of several kms for an elevated point source should be considered. It should be noted that the ADMS terrain module has been verified in many case studies by CERC using observed single point met data. To date CERC have not identified double counting as a potential issue when using locally observed met data.

5) For probabilistic accident consequence assessments, the investigation should consider the impact on model endpoints of applying different spatially and temporally (for example 1 hour vs 3 hour) resolved NWP met data. It is important that the same NWP model is applied in order to isolate the impact of grid resolution alone. Model endpoints derived by way of radiological probabilistic accident consequence assessments are typically estimated at distances of a few kilometres to a few hundred kilometres where single site observed met data is unlikely to be representative. Therefore, there is little value in evaluating model runs applying different resolutions of NWP met data against a model run based on single site observed met data. The contractor should assess whether the differences in model endpoints derived are significant as a result of applying different resolutions of NWP met data. Or are the differences relatively small and therefore is there a greater benefit to a model user in applying more coarse data (due to significantly reduced model runtime, ease of "handling" smaller datafiles, and the potential for easier access to a specific temporal period of data and availability of large periods of unbroken data). UKHSA's PACE suite of models or a suitable alternative probabilistic accident consequence assessment code should be applied in the study.