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ATMOSPHERIC DISPERSION KNOWLEDGE GAPS AND RESEARCH PRIORITIES: RESULTS FROM A RECENT SURVEY OF ADMLC MEMBERS

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Abstract: The Atmospheric Dispersion Modelling Liaison Committee (ADMLC) is a committee composed of dispersion modelling experts and practitioners primarily, but not exclusively, from various government agencies in the UK and Ireland. Its main aim is to review current issues and facilitate the exchange of knowledge in atmospheric dispersion modelling and related phenomena. In 2018, the ADMLC ran a short expert-elicitation exercise amongst its members to categorise the topics of interest to each member, to describe the maturity of these topics, and to identify knowledge gaps and outstanding issues. This article summarises the findings from that survey, with a focus on the knowledge gaps and their level of importance to the community represented by the ADMLC membership. The issues identified in the survey span a range of subjects, including: modelling improvements, validation, logistics, sensitivity and uncertainty, guidance and communication. The top four topics, which are currently of most interest to the Committee, are: 1.) deposition, 2.) modelling of source terms in an emergency, when there is limited information available, 3.) fire source terms and associated plume rise, and 4.) understanding meteorological uncertainties. The ADMLC will seek to prioritise research on these topics in the future.

Key words: *Dispersion modelling, knowledge gaps, research priorities, ADMLC*

INTRODUCTION

The history of the Atmospheric Dispersion Modelling Liaison Committee (ADMLC) dates back to 1977, when representatives from UK government departments, utilities and research organisations convened an informal committee to discuss methods for calculating atmospheric dispersion of radioactive releases. Over the following years, this committee continued to meet and discuss developments in dispersion modelling, and the ADMLC was formally created in 1995. The initial focus of the ADMLC was on the nuclear industry, but over the years its interests have widened to reflect its growing membership, which currently includes the Met Office, Public Health England (PHE), Health and Safety Executive (HSE), Defence Science and Technology Laboratory (DSTL), Atomic Weapons Establishment (AWE), Food Standards Agency (FSA), Department for Environment Food and Rural Affairs (DEFRA), Office for Nuclear Regulation (ONR), and the Environment Agencies of Ireland, Scotland and England (EPA, SEPA and EA). These organisations make use of dispersion models to provide a number of statutory and regulatory functions, including: advice on emergency response, permitting, land-use planning, emergency planning, source attribution, incident investigation, consultancy and regulatory enforcement.

The main aim of the ADMLC is to review approaches for predicting atmospheric dispersion and related phenomena for application to authorization/licensing of discharges to the atmosphere resulting from industrial, commercial or institutional sites. Most of the interest is on fixed sources, rather than transport-related sources, including both routine releases and those resulting from accident or "upset" conditions. The ADMLC also serves a useful function in facilitating the exchange of information amongst its members and helping to coordinate work on dispersion modelling across government.

The Committee meets three times a year and it organises a public seminar or workshop every two to three years. Each member organisation contributes a yearly fee, which is currently £3,000 (€3,500), and these funds are pooled together and used to commission small research projects on topics of common interest to the ADMLC members, often in the form of reviews. In recent years, these have included projects on sensitivity of dispersion model predictions to individual source term parameters, and presentation of uncertain information in radiological emergencies. Reports on these and around 40 other studies dating back to 1979 are freely available on the ADMLC website: www.admlc.com. A number of dispersion model validation datasets and the proceedings of ADMLC Seminars are also hosted on the website. If readers know of further datasets that could be hosted by the ADMLC, please contact the ADMLC Secretariat (email: admlc@phe.gov.uk). Three ADMLC projects are currently underway or have recently been commissioned: on dispersion modelling of odour emissions, applicability of Gaussian modelling techniques to near-field dispersion, and a review of dense-gas dispersion modelling.

In 2018, the ADMLC ran a short survey amongst its members to help identify ongoing interests and prioritise future research projects. Each member was asked to list their primary areas of interest in the field of atmospheric dispersion modelling under three headings:

- Area of interest
- How mature is the topic?
- Problem to solve / what is hindering the solution?

The responses from these questionnaires were then compiled together under common headings, such as "modelling improvements", "validation" and "guidance". Each topic raised by members was ranked according to the number of members interested in that subject. The findings were discussed at a Committee meeting and members were given an opportunity to revise their submission in the light of the topics raised by other members. The final findings from that group survey are presented below.

Originally, this survey of ADMLC members' interests was intended to be kept as an internal discussion document within the Committee. However, it was felt that it would be beneficial to disseminate the findings more widely at the Harmo'19 conference, since it provides an opportunity to engage with other stakeholders and research organisations, to raise awareness of knowledge gaps, and encourage discussion of the issues and possible collaboration.

INTERESTS AND ACTIVITIES OF ADMLC MEMBERS

Figure 1 presents a breakdown of the activities of ADMLC members who have contributed to this survey, in terms of their dispersion modelling scales of interest, the hazards considered, the types of sources and the dispersion models used by these organisations. The bars charts indicate the number of member organisations interested in each aspect of a particular topic. Figure 1a shows that the members' interests span the full range of dispersion-modelling scales from indoor to global, with all members interested in "local" scale (i.e. dispersion distances of roughly a kilometre). The type of hazards of interest (Figure 1b) includes routine air quality, chemical, biological, radiological/nuclear and "other" (such as volcanic ash), with a significant proportion of the members interested in radiological/nuclear hazards. The sources of interest (Figure 1c) are very diverse, with the top three being fire/smoke, explosive and stack emissions. In terms of dispersion models (Figure 1d), all of the members use Gaussian models and a significant proportion use Lagrangian models. Most members have a strong interest in sensitivity and uncertainty analysis.

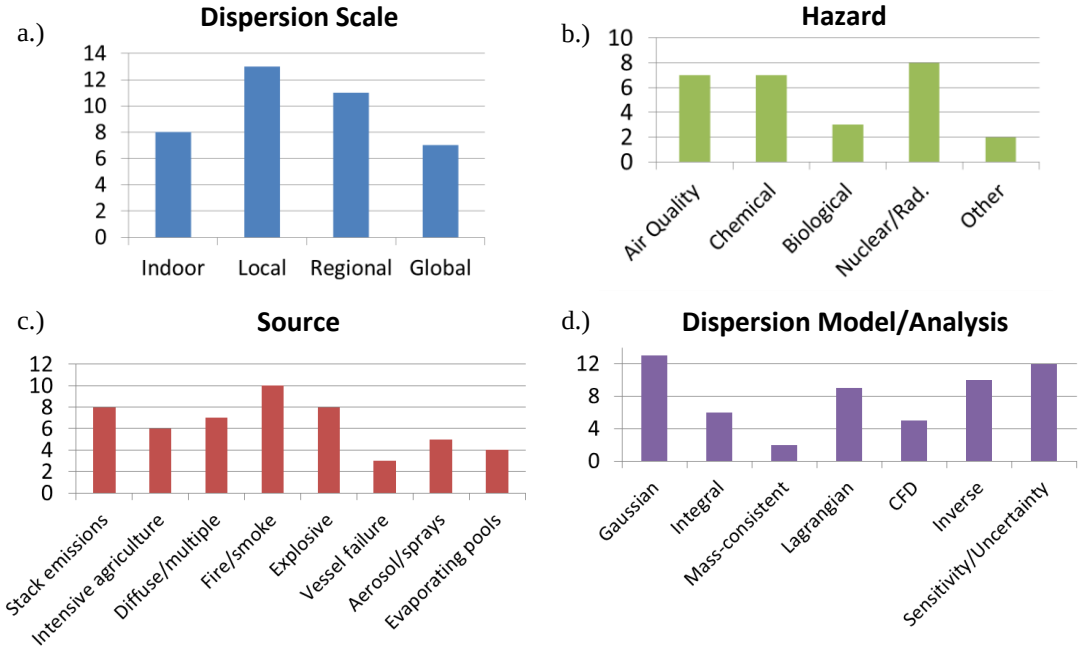

Figure 1. Interests and activities of ADMLC members in terms of: a.) the dispersion modelling scale, b.) the hazards, c.) sources, and d.) dispersion model/analysis. Vertical scales show the number of members interested in that topic.

KNOWLEDGE GAPS AND UNRESOLVED ISSUES

The ADMLC members raised a total of 83 separate knowledge gaps or unresolved issues during the survey, spanning a wide range of different topics. These were grouped under the following headings:

- Modelling improvements (e.g. source terms, complex physics)
- Validation (e.g. datasets needed, model evaluation exercises)
- Logistics (e.g. access to certain information)
- Sensitivity/uncertainty (e.g. understanding the effects of input variability)
- Guidance in the use of models (e.g. good practice for air-quality models)
- Communication (e.g. presenting results to decision-makers and the public)

There were 40 separate items raised under the "modelling improvements" heading, which is too many to go through in detail in this extended abstract. Figure 2 presents the top-ranked issues. Further details are provided in the presentation slides accompanying this extended abstract.

The highest-ranking issues under the heading "modelling improvements", supported by 9 of the 13 members, were modelling of wet and dry deposition (both of gases and particles), and modelling of sources in an emergency when there is limited information. Fire/smoke source terms and associated plume rise were also rated highly as an area needing further work. Members were interested in smoke

produced by fires at waste landfill and recycling sites, chemical fires and nuclear fires. Specific issues included the need to develop standard methodologies for the range of potential fire emergency response scenarios, the need to understand the effects of moisture, particulate loading, turbulent entrainment and impact of mitigation measures (e.g. fire-fighting), and the need to develop techniques to back-calculate source terms from monitoring data or visual observations of smoke plumes. The use of dispersion models to help design sensor networks and to interpret their data was also raised as an important issue.

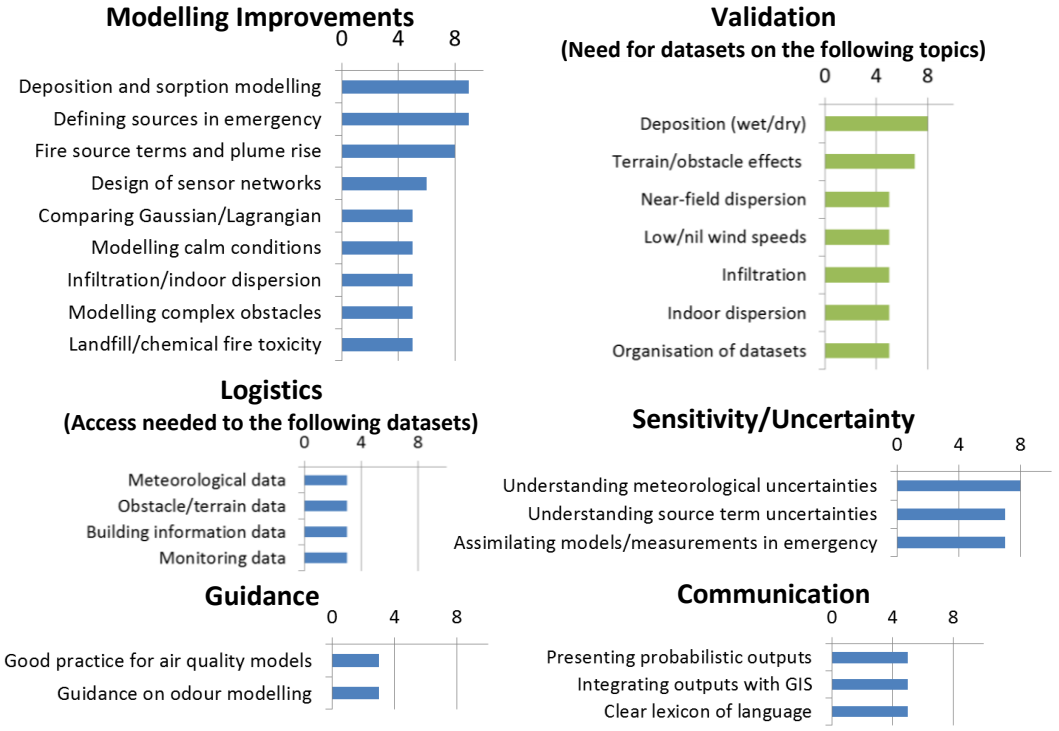

Figure 2. Knowledge gaps and unresolved issues. Scales show the number of members interested in that topic.

Deposition was the top-priority issue chosen by Committee members under the heading of "validation". Particular issues included the lack of validation data from both field-scale and laboratory experiments, especially those with high concentrations relevant to acutely toxic substances, where the deposition surface may become saturated. There was also interest in understanding how deposition varies as a function of chemical form, particle size, precipitation type and deposition surface, with notable interest in deposition within the urban environment. The ADMLC has previously published several studies on deposition, including the review by Underwood (2001) which focused on dispersion of particles and iodine for nuclear applications, and the draft review of deposition in fog by Wilkinson *et al*. (2010). It would be timely to produce an updated review of deposition, given the interest in this subject from the recent Jack Rabbit chlorine trials (Hanna and Chang, 2008; Fox *et al*., 2017) and the construction of a new deposition wind tunnel at Arkansas University (Spicer and Feuvrier, 2017). Other important issues raised under the heading of validation included datasets for atmospheric dispersion over complex terrain, where there may be important effects from topography or buildings (particularly in the near-field) and also dispersion in low wind speeds, infiltration and indoor dispersion.

The high-ranking items under the heading of "logistics" included access to meteorological data, obstacle/terrain data, building information data (for infiltration and occupancy) and monitoring data. The majority of members had an interest in the general subject of "sensitivity and uncertainty". There was significant interest in understanding the effects of meteorological and source term uncertainties, and understanding uncertainty in emergency response when assimilating data from both models and measurements. Specific issues on the last point included weighting models and measurements (depending on the confidence in the data). Other topics included propagating uncertainty through modelling systems, and developing methods suited to inverse modelling.

Under the heading of "guidance", the top issues were on guidance for modelling odour emissions and sharing of good practice for air quality models, with a focus on models applied nationally and those applied to large urban areas. The ADMLC publishes guidance on preparation of dispersion modelling assessments for compliance with regulatory requirements (Ireland *et al*., 2004). This guidance is currently being revised and a new edition should be published in late 2019 or 2020.

The final heading of "communication" included a range of specific items on topics such as: presenting probabilistic estimates of exposure and uncertainty, use of a clear lexicon of language, and communicating results using Geographical Information Systems (GIS).

DISCUSSION AND CONCLUSIONS

The wide-ranging review of atmospheric dispersion modelling knowledge gaps by the ADMLC identified 83 separate issues. The top four issues currently considered by the Committee as being of most interest were:

- Wet and dry deposition (both of gases and particles)
- Modelling of source terms in an emergency, when there is limited information available
- Fire source terms and plume rise (including landfill, chemical and nuclear fires)
- Understanding the impact of meteorological uncertainties

The Committee will seek to prioritise research on these topics in the future and it would welcome discussions with experts and other funding agencies that share similar interests. The ADMLC plans to hold a public seminar and workshop in September 2019 to discuss some of the issues raised in this article in the context of emergency planning and response.

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