Atmospheric Dispersion Modelling Liaison Committee (ADMLC)

19th conference on "Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes", Bruges, Belgium, June 3-6, 2019

Atmospheric dispersion knowledge gaps and research priorities: Results from a recent survey of ADMLC members

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HARMO19

Overview

- Background to the ADMLC
- Aims
- Survey questions
- Interests and activities of ADMLC members
- Knowledge gaps and other issues
- Summary

Background to ADMLC

- **1977**: Representatives of UK government departments, utilities and research organisations met to discuss calculation methods for atmospheric dispersion of radioactive releases
  - Informal steering committee formed to review recent developments in dispersion modelling (predecessor to ADMLC)
- **1995**: ADMLC formally formed with an initial focus on the nuclear industry
- **Since 1995**:
  - Focus widened to include range of interests of its members, including UK and Irish industrial and regulatory organisations
  - **Aim**: to review atmospheric dispersion and related phenomena for application primarily to authorization or licensing of discharges to atmosphere resulting from industrial, commercial or institutional sites
  - Main interests on fixed sources, rather than transport sources, including both routine releases and releases in accident or “upset” conditions

Background to ADMLC

Current membership:

Background to ADMLC

- ADMLC Committee meetings held 3 times per year
- Each member organization contributes £3k each year
- ADMLC public workshop/seminar every 2 to 3 years
- Small research projects commissioned, e.g.:
  - Modelling pollutant dispersion from non-point sources (2016)
  - Presenting uncertain information in radiological emergencies (2016)
  - Sensitivity of dispersion modelling results to source terms (2017)
  - Dispersion modelling of odour emissions (ongoing)
- New Projects:
  - Applicability of Gaussian modelling techniques to near-field dispersion
  - Dense-gas dispersion for industrial regulation and emergency response
- Dispersion model validation datasets, e.g. Thorney Island
- Reports and datasets publicly available: http://www.admlc.com

Aims

- Conduct survey amongst the ADMLC committee members to:
  - Identify common interests
  - Prioritise future ADMLC research
- Originally intended as ADMLC internal discussion

- Objective of disseminating more widely at Harmo'19:
  - Engage with other stakeholders and research organisations
  - Raise awareness of knowledge gaps
  - Encourage discussion of issues and collaboration

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Survey Questions

ADMLC members asked to complete a questionnaire on:

"Primary areas of interest in the field of atmospheric dispersion modelling"

Three headings:

Area of interest

How mature is the topic

Problem to solve / what is hindering the solution?

Example:

Primary area(s) of interest in the field of atmospheric dispersion modelling

Organisation	Health and Safety Laboratory	
Person completing form	Simon Gant	
Area of interest	**How mature is the topic**	**Problem to solve / what is hindering application of solution**
Local-scale dispersion (5 m to 5 km range): • Dense/passive/buoyant gases • Flammable/toxic substances • Multi-component gases • Water-reactive substances • Terrain/obstacle effects	• Many field-scale trials undertaken since 1970's • Various Gaussian, integral, shallow-layer, Lagrangian and CFD models developed/validated • Models in widespread use for risk assessment • Uncertainties still remain, particularly in: terrain/obstacle effects and water-reactive substances	• Lack of validation data for terrain/obstacle effects • Lack of data for low/nil wind speeds • Uncertainties for reactive substances (for deposition effects – see below)
Complex source terms, e.g.	• Many experiments conducted since 1970's, primarily	• Lack of validation data for larger-scale releases

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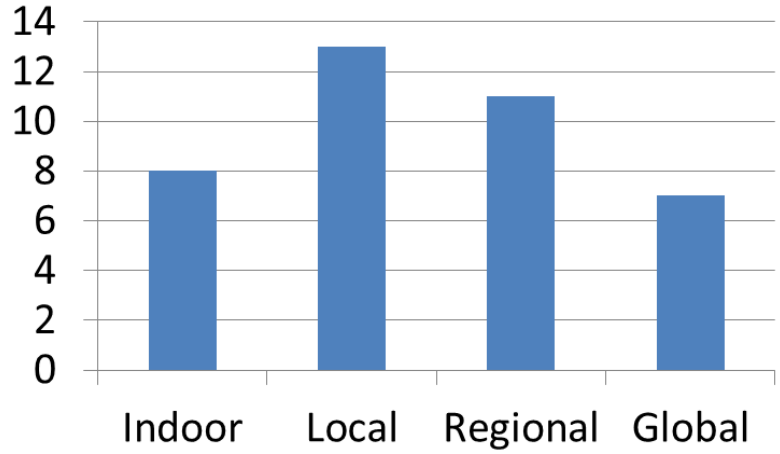
Interests and activities of ADMLC members

Grouping of topics used on later slides:

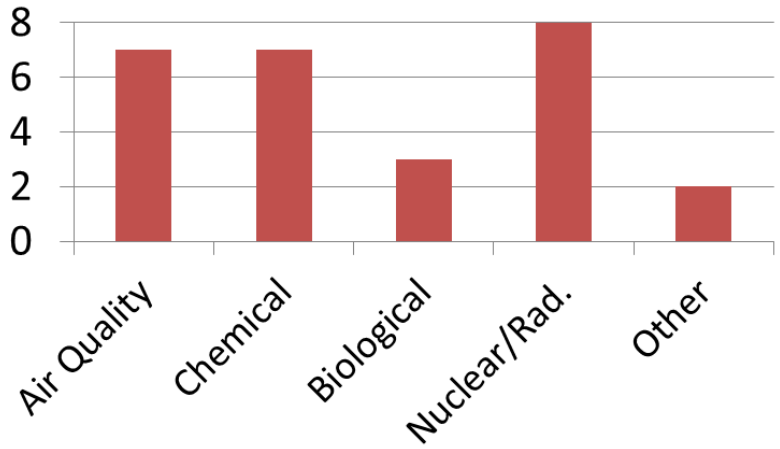
- **Dispersion modelling scale** (indoor, local, regional, global)
- **Hazard** (e.g. air quality, chemical, biological, radiological)
- **Consequences** (e.g. acute effects, long term effects, odour)
- **Tasks** (e.g. emergency response, source attribution, permitting)
- **Substance of interest** (e.g. gas, particulate, liquid aerosol)
- **Source terms** (e.g. stack emission, fire, spray, evaporating pool)
- **Physics** (e.g. dense, passive, dry deposition, atmospheric chemistry)
- **Models used** (e.g. Gaussian, Lagrangian, CFD)

Interests and activities of ADMLC members

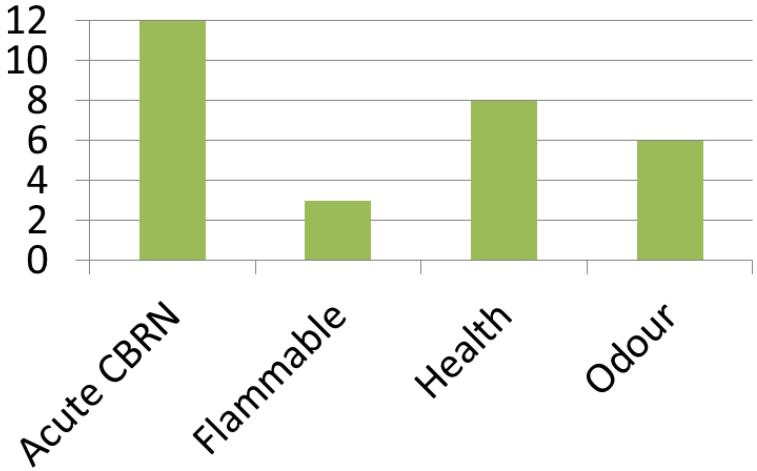
Dispersion modelling scale



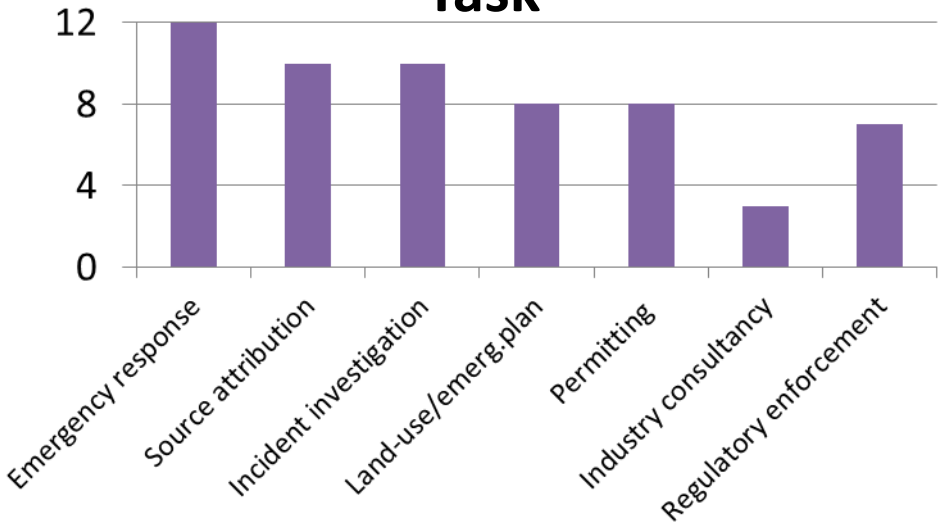
Hazards



Consequence

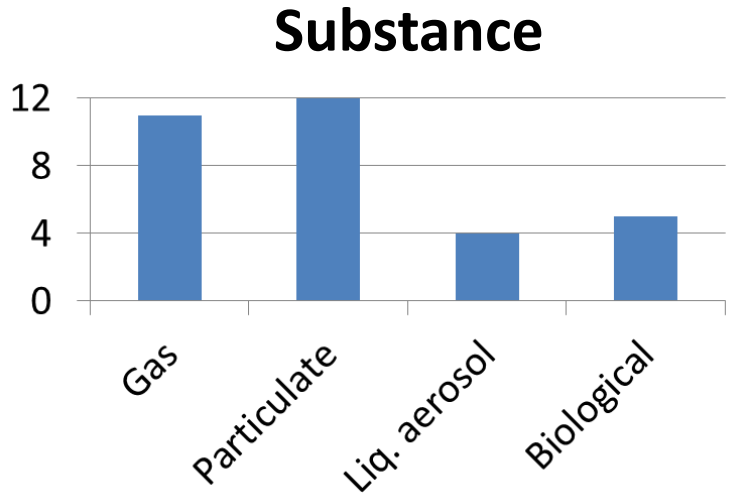


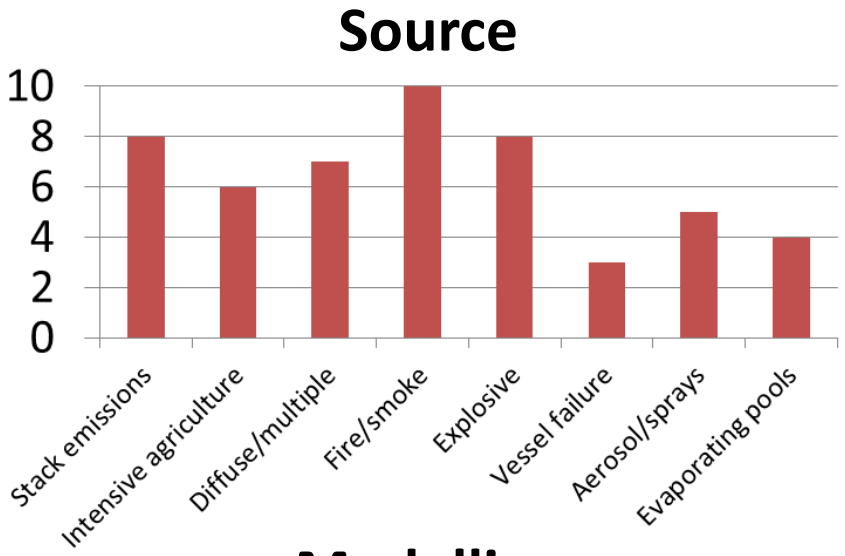
Task

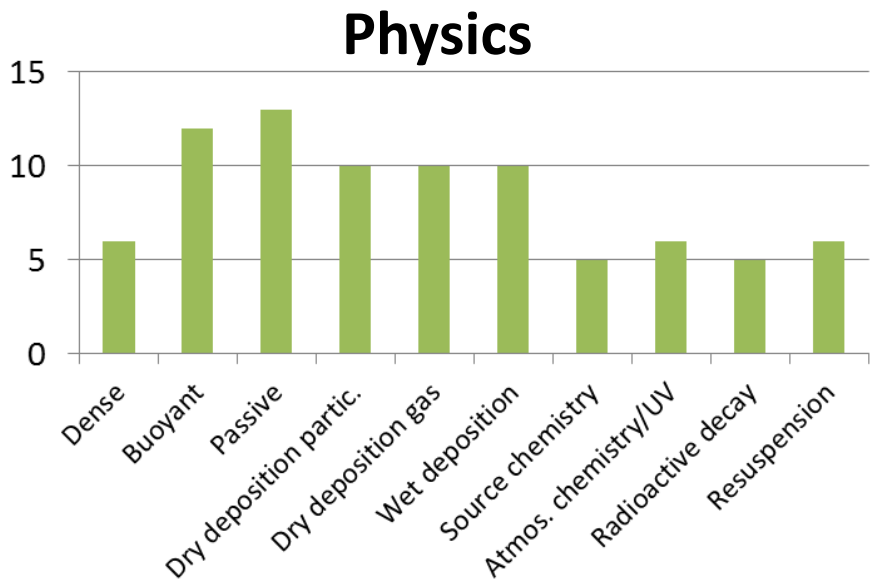


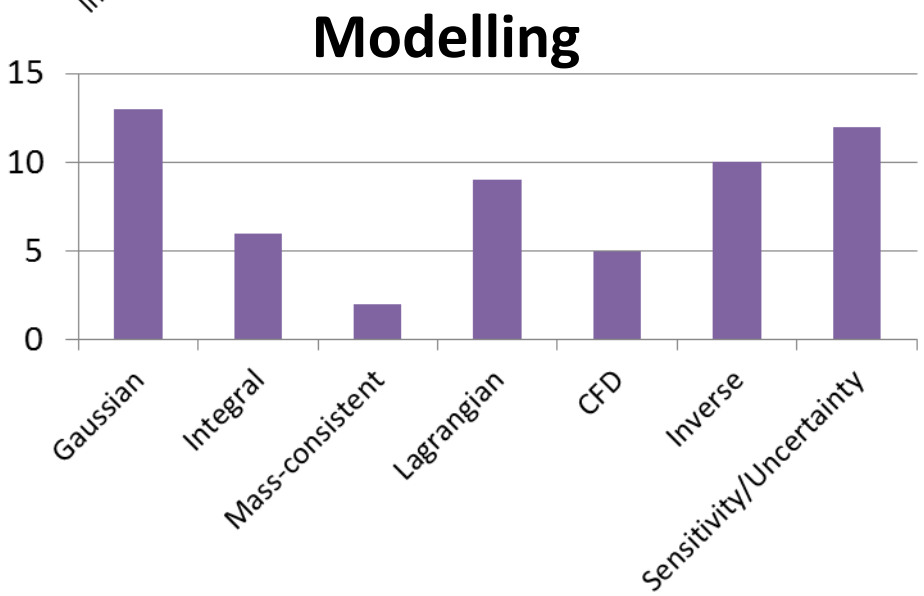
Vertical scales shows number of ADMLC member organisations with interest in that topic

Interests and activities of ADMLC members









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Knowledge Gaps and Other Issues

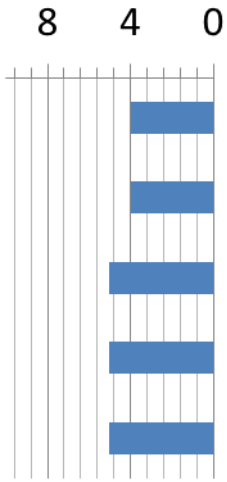
Grouping of topics used on later slides:

- **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** (e.g. good practice for air-quality models)
- **Communication** (e.g. presenting results to decision-makers and the public)

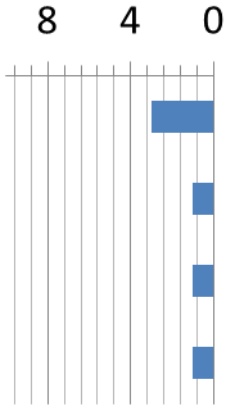
Total of 83 separate issues raised

40 issues alone under the heading of “modelling improvements”

Modelling Improvements Needed



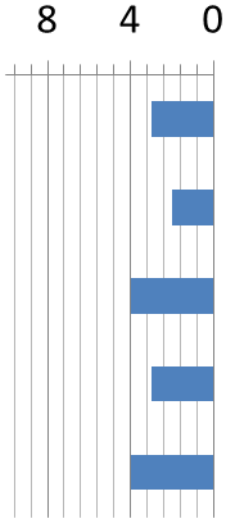
- Gaussian models
  - Improve downwash effects (currently under-predicted)
  - Improve modelling of wake and cavity regions
  - Improve modelling of sources within complex obstacle arrangements
  - Comparison of Gaussian to Lagrangian models for societal risk
  - Modelling of calm conditions



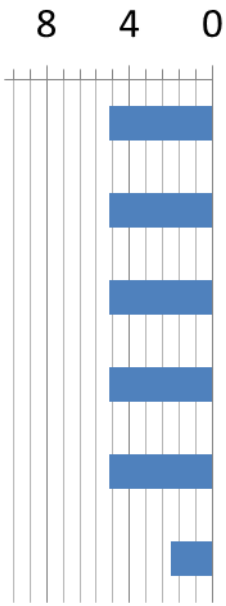
- Dense-gas models
  - Investigate simple dense-gas dispersion models for emergency response
  - Review past incidents to understand trends and characterise model inputs
  - Models for dense gas dispersion in low/nil-wind speeds (not full CFD)
  - Interaction of dense gas with complex meteorology

Horizontal scales shows number of ADMLC member organisations with interest in that topic

Modelling Improvements Needed

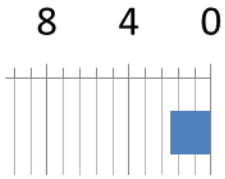


- CFD
  - Improve modelling of atmospheric boundary layers with RANS
  - Reduce financial costs of software and computing
  - Reduce runtimes
  - Improve user repeatability
  - More consistent validation for wider range of experiments

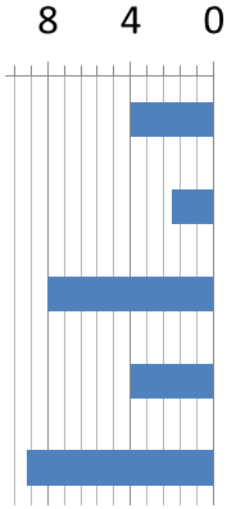


- Indoor/infiltration models
  - Develop models for non-fully-mixed rooms, stratification, sedimentation
  - Improve modelling of ventilation systems
  - Definition of inlets/outlets and external pressures
  - Air change rates in naturally-ventilated buildings
  - Dispersion in large indoor spaces, e.g. shopping malls
  - Benchmarking of the PHE infiltration tool INGRESS

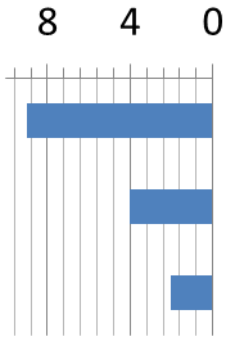
Modelling Improvements Needed



- Meteorological models
  - Boundary layer, urban processes, precipitation, turbulence

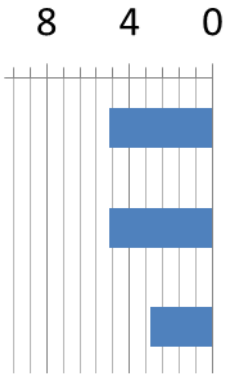


- Source terms
  - Explosive source terms
  - Spreading evaporating pools, flashing jet sources
  - **Fire source terms and plume rise (landfill, chemical, nuclear)**
  - Fire source modification from intervention (e.g. water spray, digging out)
  - **Definition of sources in an emergency, with limited information**

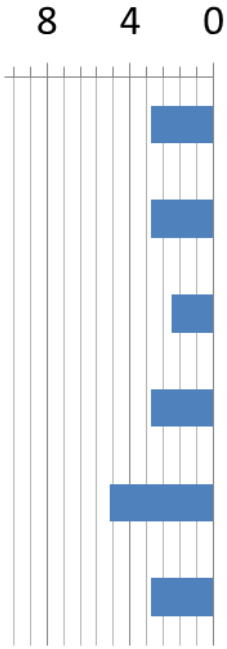


- Complex physics
  - **Models for deposition and sorption (including saturation effects)**
  - Dispersion in coastal areas with sea breezes
  - Temporal variability of radionuclides in different chemical forms

Modelling Improvements Needed

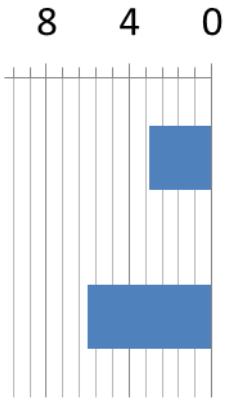


- Inverse models and data assimilation
  - Simple models for identifying sources based on public complaint data
  - Quantifying measurement uncertainty effects on outputs
  - Mathematical frameworks for optimal solution



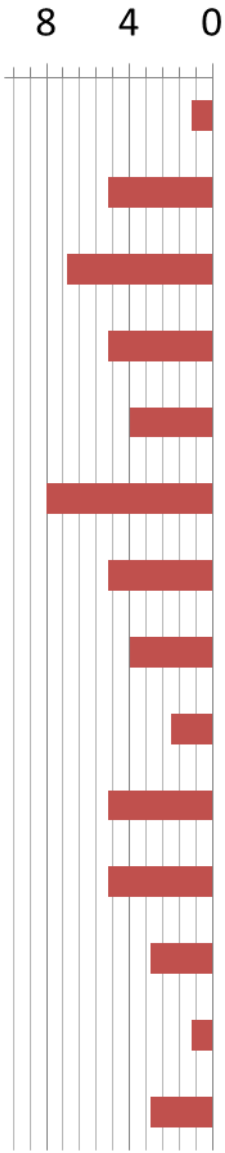
- Toxic effects
  - Uncertainty in toxic load models
  - Concentration fluctuation effects
  - Extrapolation from animal studies to humans
  - Assessing effect of variability in human population
  - Definition of toxic effects for landfill fire, chemical fire
  - Annual average dose calculations: evaluate the benefits of using the Met Office NAME Lagrangian model

Modelling Improvements Needed



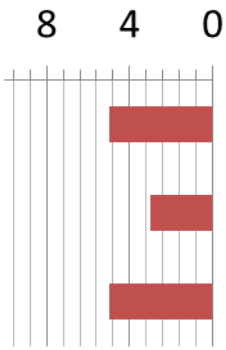
- Other
  - Modelling psycho-social/behavioural aspects for shelter-in-place advice (response, compliance, effectiveness of action)
  - Use of dispersion models to help design sensor networks and to interpret their data

Validation



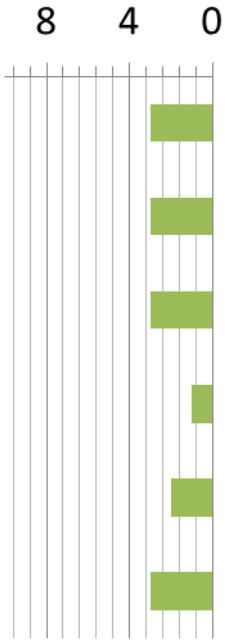
- Experimental data needed for:
  - Dispersion from explosive releases in different environments
  - Near-field dispersion
  - **Terrain/obstacle effects**
  - Low/nil wind speeds
  - Urban stability effects
  - **Deposition (wet/dry)**
  - Sorption on/in buildings
  - Material degradation (e.g. photolysis)
  - Dispersion during precipitation, fog etc.
  - Infiltration from outdoor to indoor environments
  - Indoor dispersion with buildings
  - Toxic effects, especially with fluctuating concentrations
  - Volcanic sources
  - Large (field-scale) dispersion studies

Validation



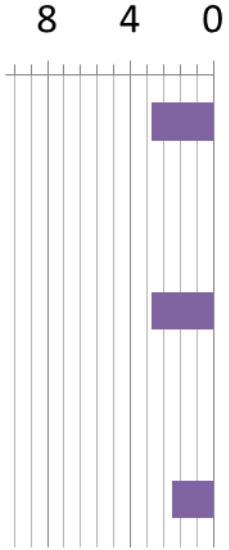
- Model evaluation
  - Datasets need to be organised / coordinated
  - Source model evaluation protocols needed, including validation database
  - Standards for assessing different types of model performance needed for different classes of models, e.g. source models (FAC2, MG, VG criteria?)

Logistics



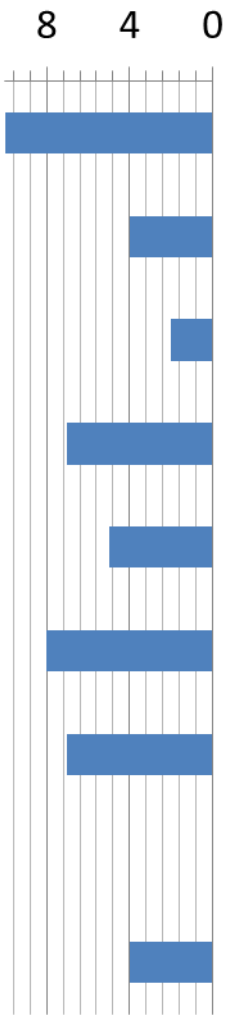
- Improved access needed to:
  - Meteorological data
  - Obstacle/terrain geometry data
  - Building information (for infiltration and population)
  - Traffic data
  - Regulated emission source data
  - Monitoring data

Guidance



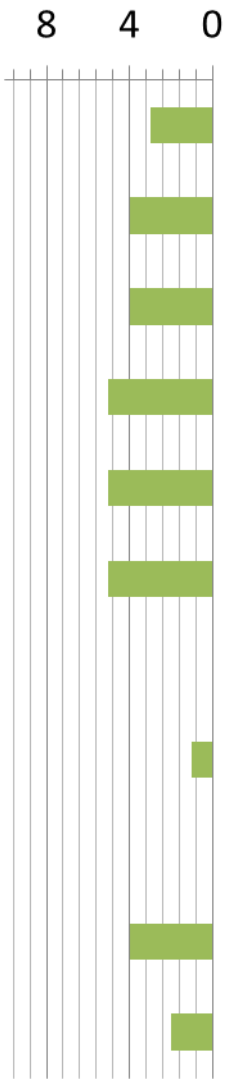
- Air quality models
  - Sharing of good practice for air quality models, nationally and in urban areas
- Odour modelling
  - Guidance on modelling and assessing uncertainties
- Shelter-in-place advice
  - Guidance on where best to shelter within a building

Sensitivity/Uncertainty



- **Assessing uncertainty (general)**
- Nuclear emergency preparedness
- Receptors near to the source
- Understanding effects of source term uncertainties
- Multiple point sources
- **Understanding the effects of meteorological uncertainties**
- Uncertainties when assimilating data from both models and measurements in emergency response
- Frameworks for efficiently sampling uncertainty space

Communication



- Communication with nuclear emergency response decision makers
- Cases with complex urban terrain, where results are difficult to interpret
- Public usage and interpretation
- Clear lexicon of language: input from statistics and comms experts
- Presenting probabilistic estimates of exposure/uncertainty
- Integrating outputs with GIS systems, also with other datasets e.g. measurements from third-parties
- Development of scenario-based guidelines for representative fire/chemical incidents with protective action distances
- Interfacing dispersion models with impact and decision-making models
- Production of indoor-at-risk maps (evolving over time) to complement outdoor risk maps for shelter-in-place advice

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Summary

- Top four topics for future ADMLC research projects?
  1. **Deposition modelling**
     - Review of dry/wet deposition modelling of gases and particulates
  2. **Modelling of sources in an emergency**
     - When there is limited information available
  3. **Fire source terms and plume rise**
     - Including landfill, chemical and nuclear fires
  4. **Understanding the impact of meteorological uncertainties**
- Partnership with other funding agencies or self-funding research organisations on topics of mutual interest?
- ADMLC seminar at PHE, Harwell, UK in autumn/winter 2019
- Come and talk to us

Thank you

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This work was funded by each of the respective ADMLC contributor's organisations. The contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect the policy of those organisations