[dstl] The Science Inside

Dstl Current Research Topics

ADMLC Spring Meeting – March 2022

Ministry of Defence

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Atmospheric Dispersion Modelling (ADM) at Dstl

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- Dstl provide impartial, evidence-based advice to a range of UK Gov customers
- Dispersion modelling is used to support requirements with widely ranging time-frames and remits:

Ministry of Defence

Department for Transport

Home Office

Minutes – hours	Weeks – months	Months – years
Operational support	**Modelling studies**	**Long-term research**
• Emergency response • Force protection	• Hazard assessments of emerging threats • Policy & doctrine	• Support to procurement • Model development

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Contents

- Atmospheric dispersion modelling (ADM) research
  - PALM
  - LES – Gaussian comparison
  - Re-aerosolisation
- Uncertainty quantification/visualisation
  - Modelling framework
  - Visualisation research
- Biological Aerosol research

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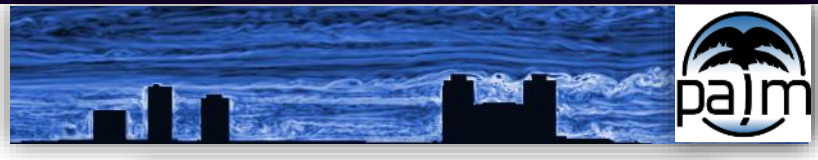
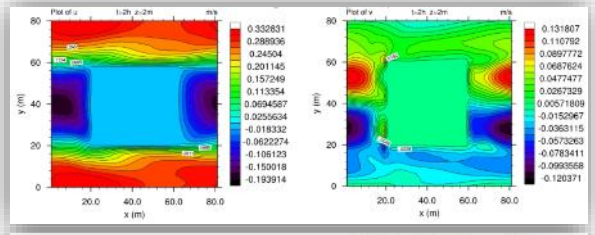
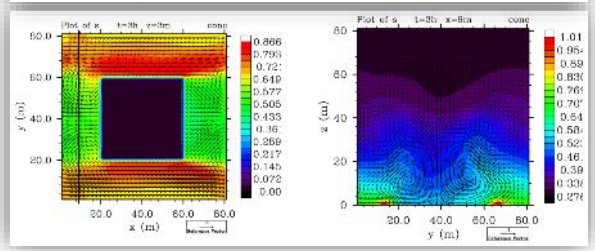
ADM Research - PALM

- Traditional operational models (e.g. Gaussian) do not fully resolve complex environments
- High-fidelity LES models often have high information & compute requirements
- PALM is an open-source LES/RANS software that can run in near-real-time and is highly scalable
- Add-ons and tools facilitate setup/analysis/visualisation
- Ongoing collaboration with Uni. of Soton for LES training







Leibniz Universität Hannover

University of Southampton

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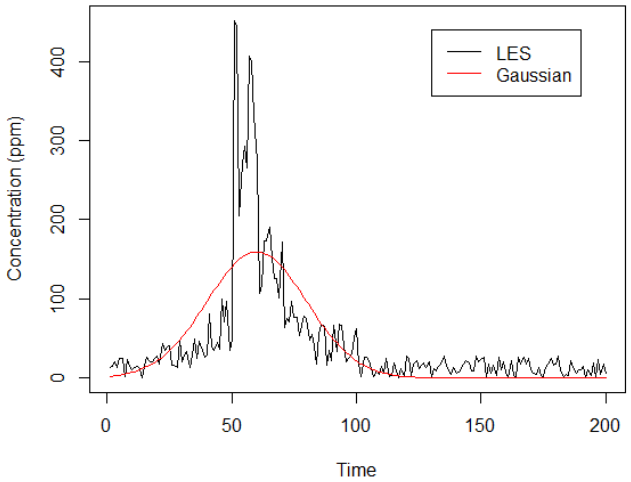
ADM Research – LES v Gaussian

- Gaussian models are fast running but inherently lack fidelity – ***does this matter?***

- High toxic load exponent (TLE) materials
  - TLE = 1 : human response is directly proportional to total exposure
  - TLE > 1 : peaks in concentration are more hazardous than longer, low-level exposure

- Sensors
  - Algorithms may respond to rapid changes/deviation from a moving average, which would be missed when using a Gaussian profile
  - Does using an LES profile improve sensor modelled performance?



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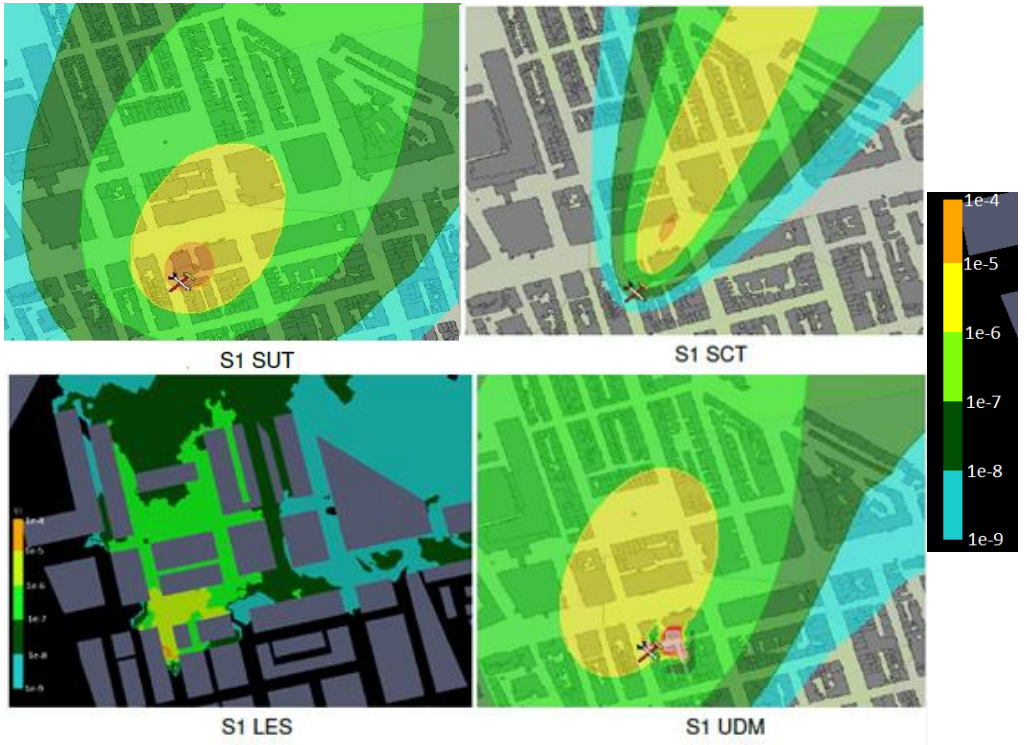
ADM Research – LES v Gaussian

- Do Gaussian models under-predict hazards where concentration peaks are important?

- Despite visual differences in plume (as expected), numeric data compared well
  - Gaussian over-predicts areas of zero concentration (e.g. upwind)

- Casualty estimates were similar
  - Areas of high concentration are small
  - Gaussian methodology did not under-predict casualties



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ADM Research – Re-aerosolisation

- Deposited particulates could pose a long-term hazard if lofted back into the atmosphere via:
  - Natural resuspension (wind)
  - Human activity (vehicle movement, footfall etc.)
- Physics is complex and processes occur at different resolutions
  - Review work at varying scales
  - Determine if/how to combine models
  - Understand low-level and wide-scale risks

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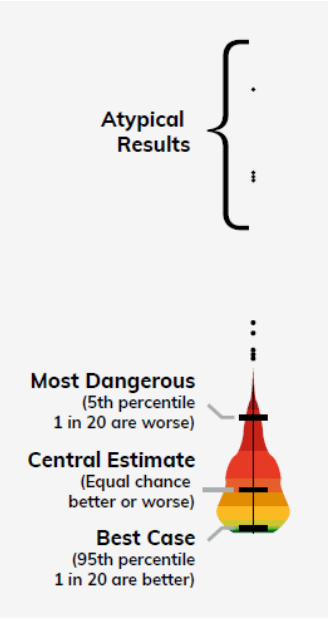
Uncertainty Quantification

- Customers typically want single number answers
  - Don’t always appreciate what they are asking for, particularly “worst-case”
- Worst-case can be quick to generate and easy to justify
  - However, is often a gross over-estimate (when combined with likelihood)
  - May not be useful/practical for planning against
- Advances in computing/methods means we are able to account for uncertainty and generate a range of answers in reasonable time-frames
  - Correspondingly, we require methods for making that data accessible and actionable



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Uncertainty Quantification – Modelling Framework

- Developing a generic, flexible framework to allow models and scripts to be chained
- Aims:
  - Allow us to easily conduct large statistical analyses
  - Generate reproducible analytic pipelines
  - Improve re-use and auditability of data
  - Make statistical methods standard practice
- Three primary uses:
  - Automate data handling between model chains
  - Conduct large, statistical studies and analyses
  - Allow models to interact at run-time

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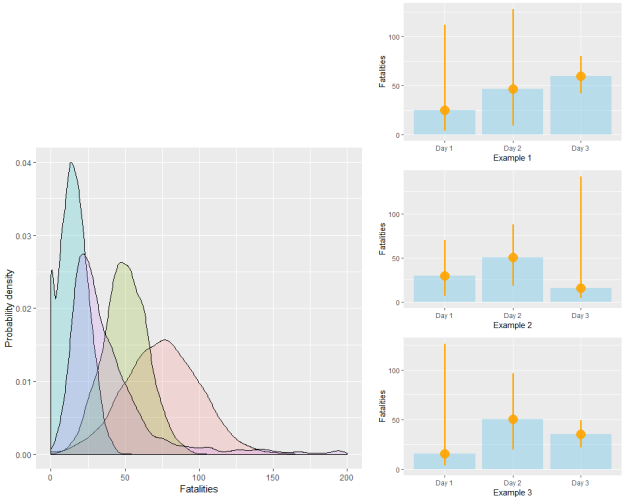
Uncertainty Visualisation

- Research to develop and test methods for presenting uncertain data to various audiences
- Workshops to generate ideas of visualising:
  - Uncertain numerical data
  - Uncertain geospatial data
- Testing via the Winton Centre (University of Cambridge) to assess effectiveness of presentation techniques
  - Does inclusion of uncertainty:
    - Aid/hinder interpretation of the data?
    - Improve confidence in decision making?
    - Improve quality of decision making?
  - Which methods are most effective for communicating uncertainty?
  - Do different demographics interpret uncertainty differently?



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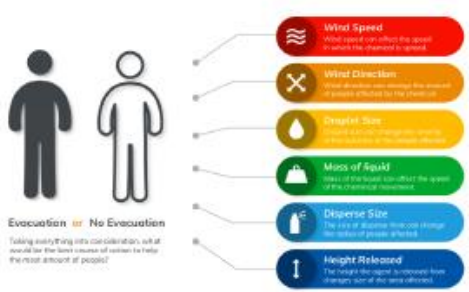
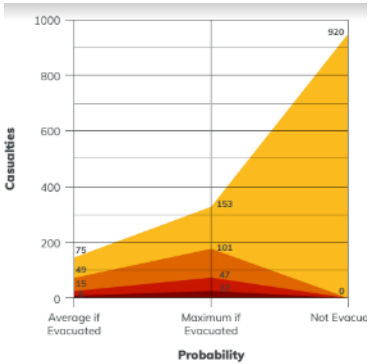
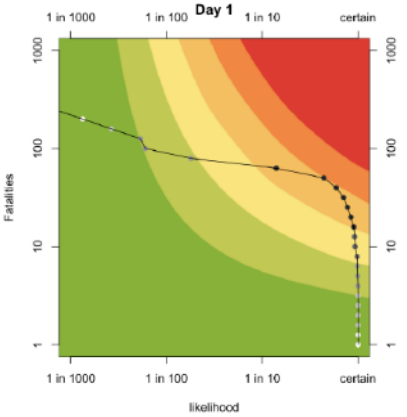
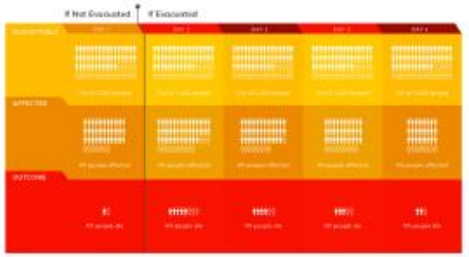
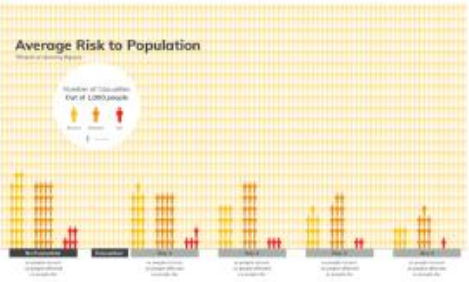
Uncertainty Visualisation

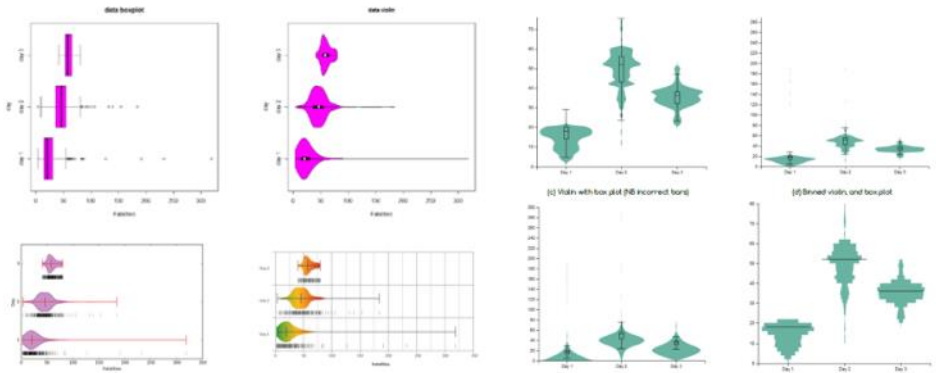












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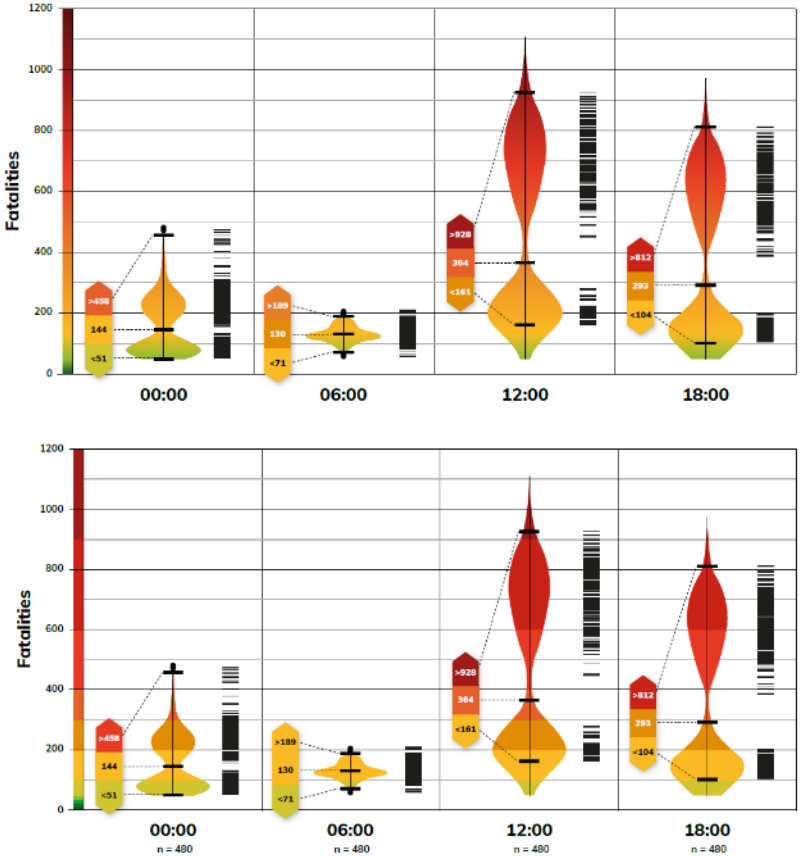
Uncertainty Visualisation



- Colour comes with preconceptions of meaning
- This can be powerful for aiding interpretation but also dangerous if not clear/taken out of context
- Too much/many colour/s and it loses meaning

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Uncertainty Visualisation

- Geospatial data is preferred by many customers (especially military)
- Very effective at presenting the scale of a hazard to non-specialist audiences
- However:
  - Very quickly becomes overwhelming
  - Often poorly interpreted

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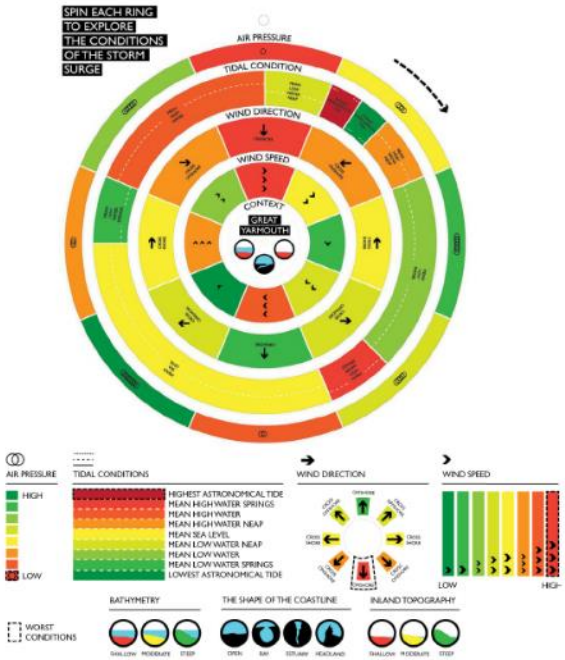
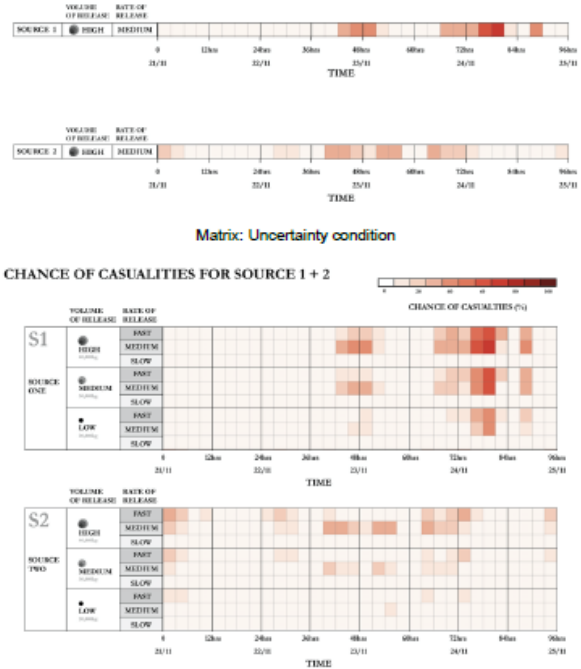
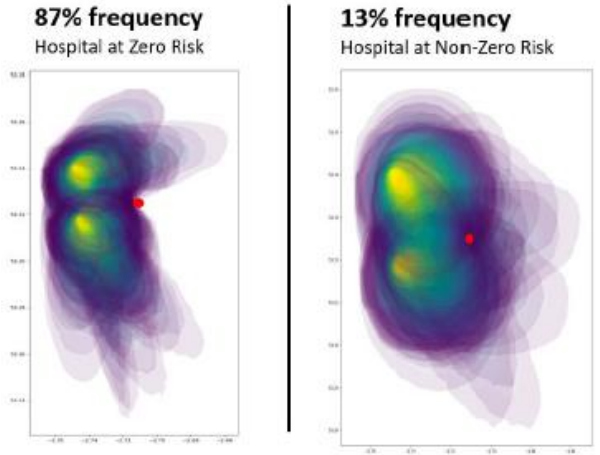
Uncertainty Visualisation

https://www.floodnarratives.com/.







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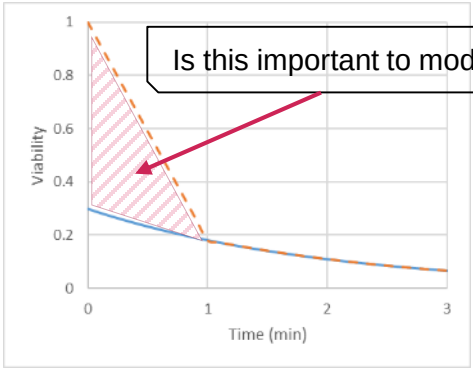
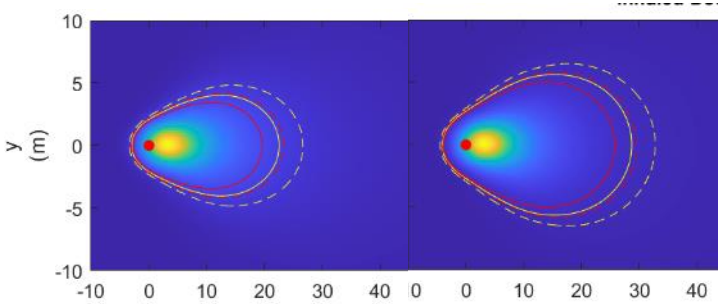
Bio-aerosol Research

- Research with University of Bristol into properties and viability of bio-aerosols
- Studying phys/chem properties of droplets and viability with sub-second resolution
- How rapidly does viability-loss occur following aerosolisation?
  - Why does this happen?
  - Is this important to model?
- Effect of growth media on evaporation (and therefore T&D)





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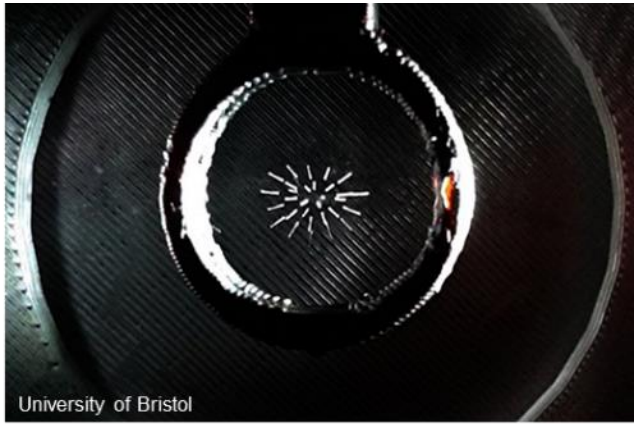
CELEBS

- *Controlled Electrodynamic Levitation and Extraction of Bioaerosols onto a Substrate* equipment developed by University of Bristol
- Aerosol droplets suspended – truly airborne and true T-zero
  - *Droplet on demand* piezo dispenser (10-100 µm equilibrated size)
  - Controlled environmental conditions
  - Precise control (sub-second) over levitation duration
- For studying airborne viability of bio-aerosols
- Used extensively in Sars-CoV2 studies
- Work at UoB studying root causes of viability loss



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