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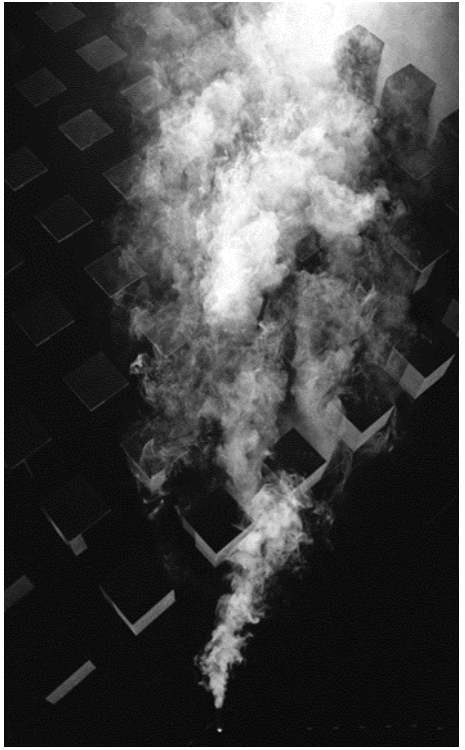
Dispersion modelling for sensor network design and inverse modelling

Prof. Veronica Bowman

Ministry of Defence

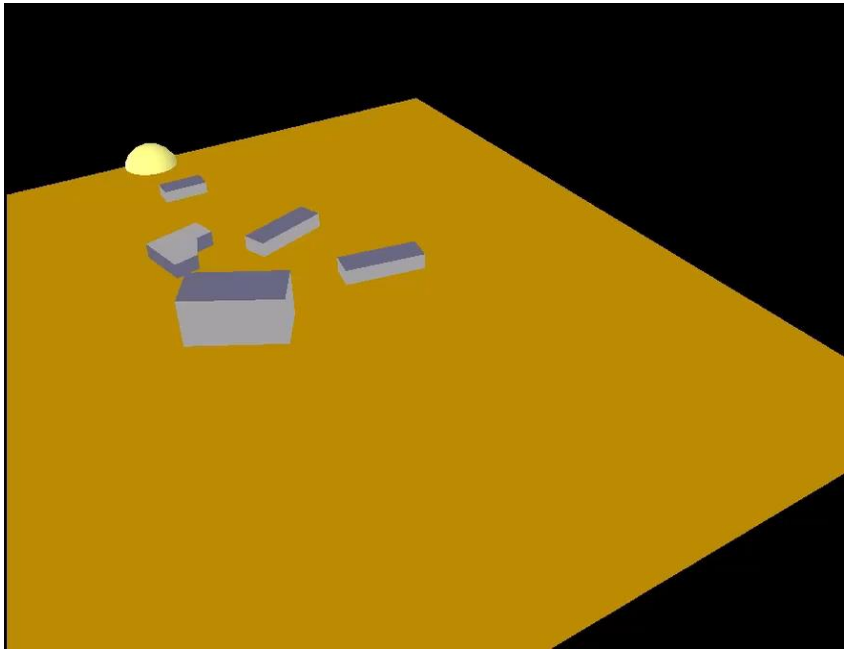
Dispersion Modelling

- To determine the optimal placement of a sensor network we need four high level inputs
  - Source
  - Meteorology
  - Terrain / Building data
  - Dispersion model



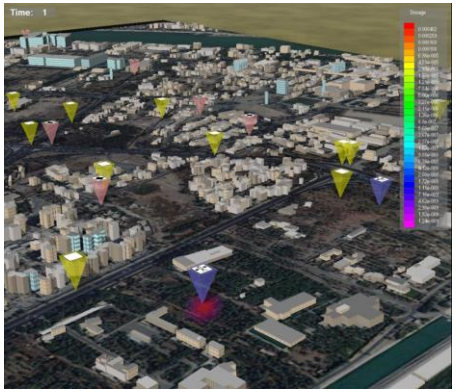
What is the aim?

- Sensor networks are placed for many reasons, but they generally have only four main aims
  - To detect a hazard
  - To localise an area of contamination
  - To predict a future hazard
  - To find the original source of a hazard



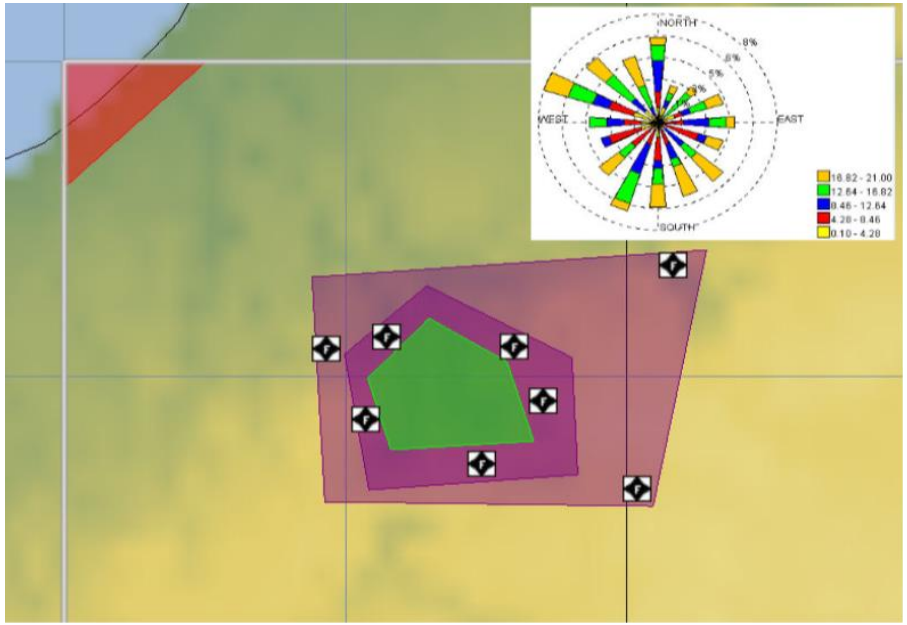
Network Type

- There are many types of sensor
  - Fixed / Moving
  - Complex / Simple
  - Algorithmically networked
- Developing and deploying the right network and mix of sensors in the right places is crucial



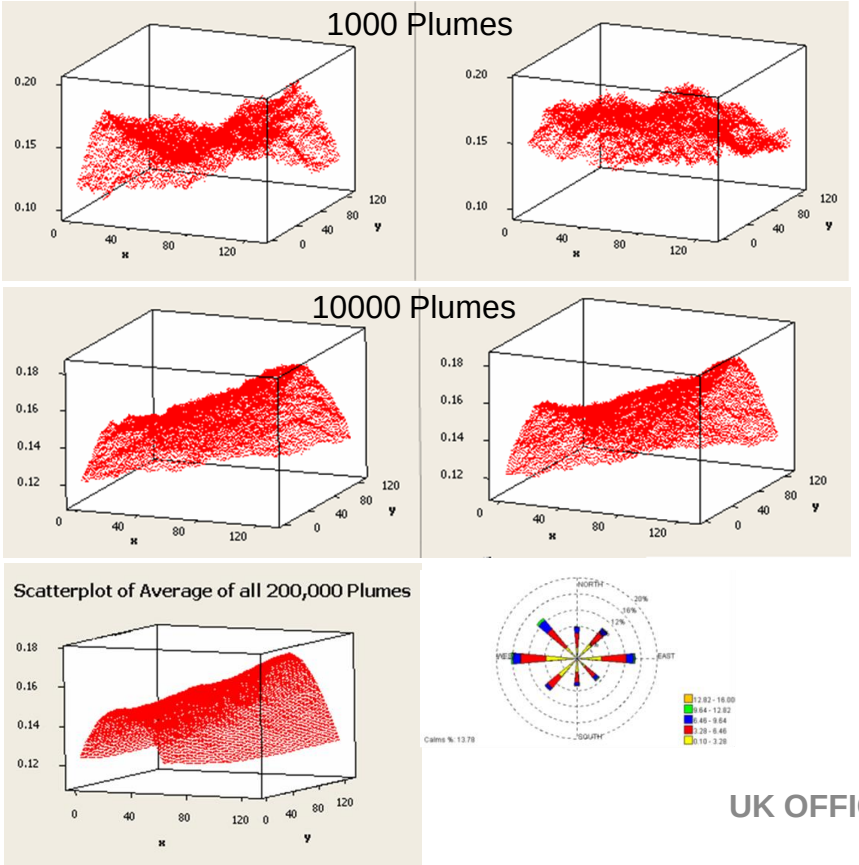
Optimization

- Ideally a sensor network would be optimised for a specific aim
- Each aim is dependent on the varying inputs
- To properly optimise, a fitness function must be generated which is entirely dependent on the dispersion model and input data



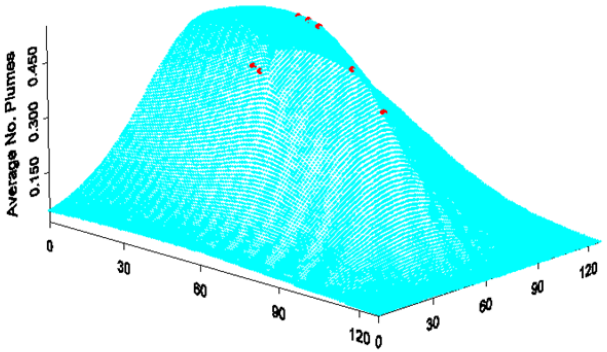
A Simple System

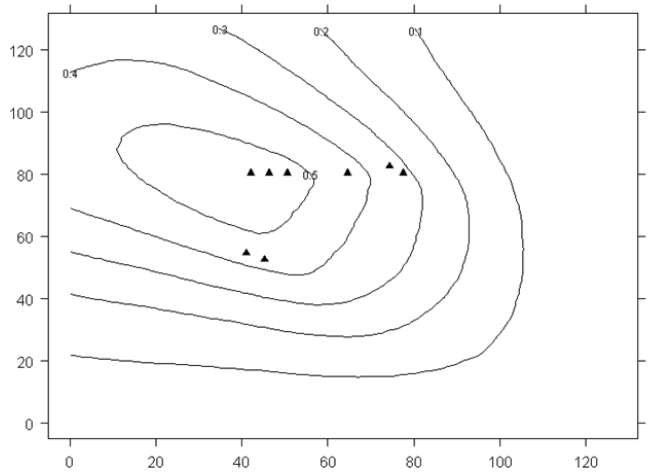
- Even using a simple Gaussian dispersion model with very course meteorology and no additional factors requires a substantial number of model runs to stabilise



A Simple System

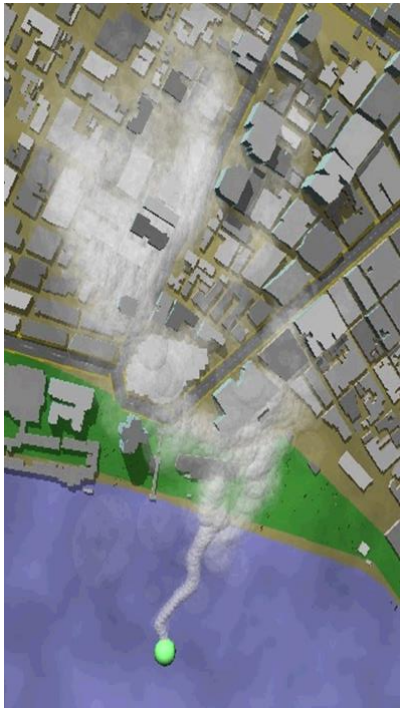
- Placement on even a smooth surface requires understanding of
  - The sensor properties
  - The correlation structure within the underpinning plume
  - The interaction between each sensor in the grid





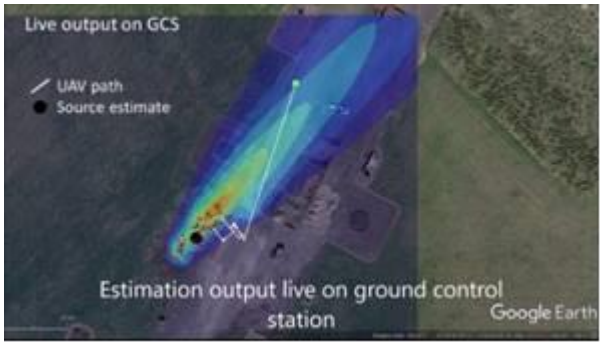
A More Complex System

- Optimal placement becomes complex quickly
  - Optimization for Source estimation
  - Optimization for a mixed or complex system
  - Optimization for moving sensors
  - Optimization accounting for non approximated flows



Where are we now?

- Optimal placement for simple systems
- Initial capability to model correlation within plume structure
- Ability to undertake plume tracking and inverse modelling
- Optimization with complex dispersion modelling

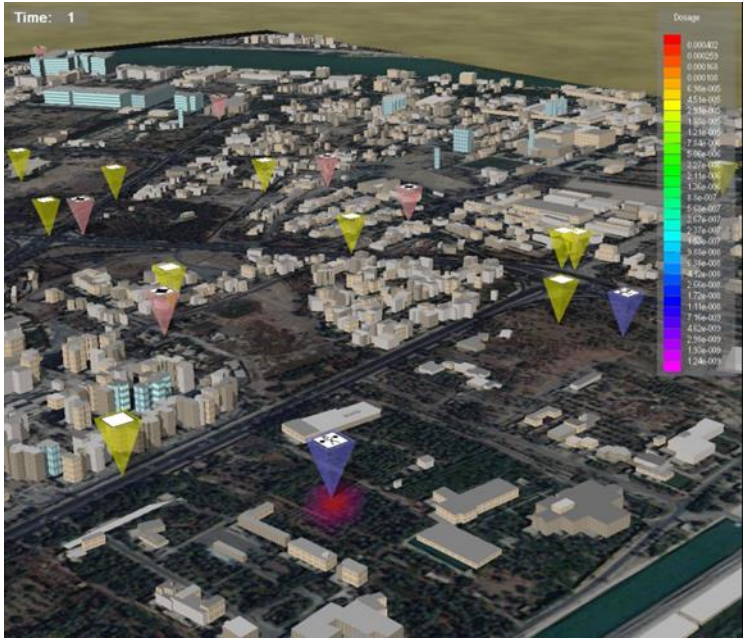


What is pushing the boundaries?

- Multi sensor systems
- Complex meteorology in conjunction with dispersion
- Accurate correlation assessment
- Breaking the feedback loop of network algorithm and placement
- Optimization for source term estimation

Potential Ways forward

- Integrated systems
  - Physics models of sensors mapped into almost real world modelling
  - Multi-fidelity dispersion modelling utilising emulators with ultra low level high fidelity modelling
  - Real time dispersion modelling harnessing fine scale meteorology



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