ERCOFTAC Uncertainty Quantification in Industrial Analysis and Design – SIG 45

Autumn Meeting, 12 November 2012, Manchester, UK

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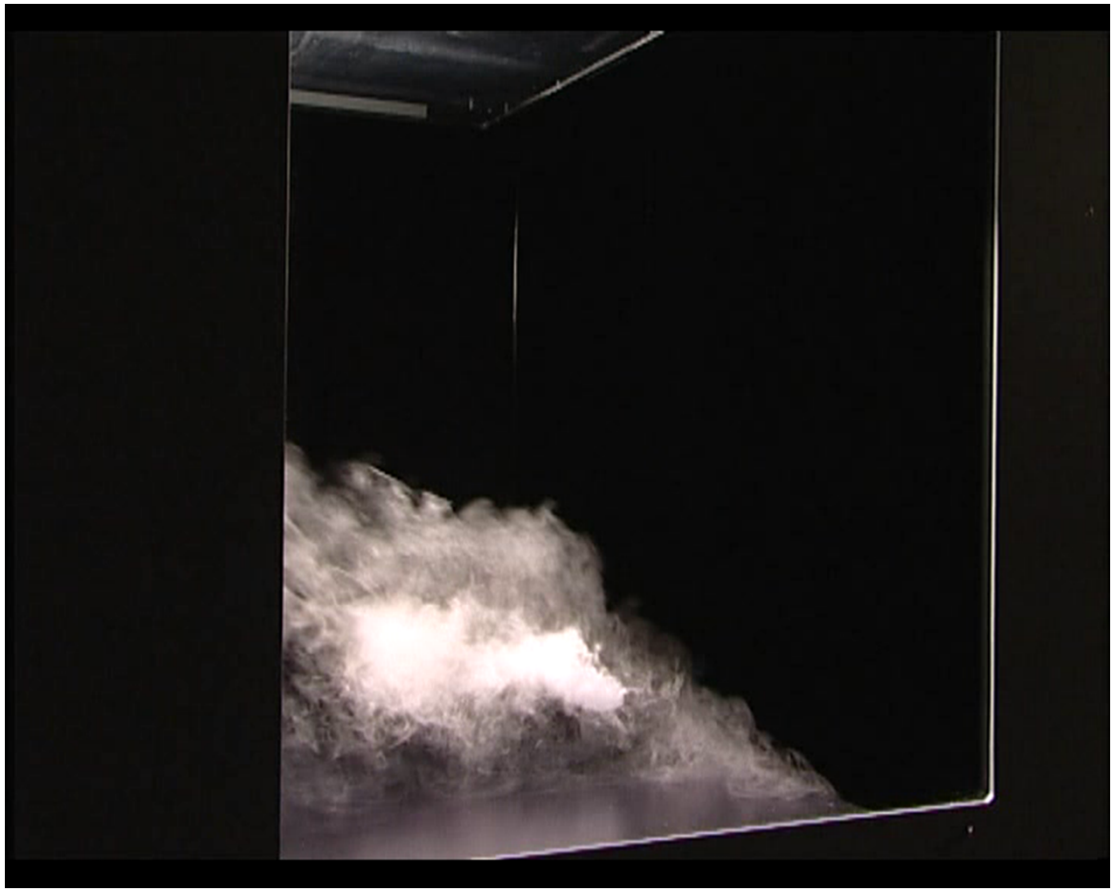
Contents

- HSL areas of interest
- Examples of our previous sensitivity and uncertainty analyses
- What we would like to achieve with SIG45 (and ideas for potential funding proposal)
- Possible case study

Areas of Work

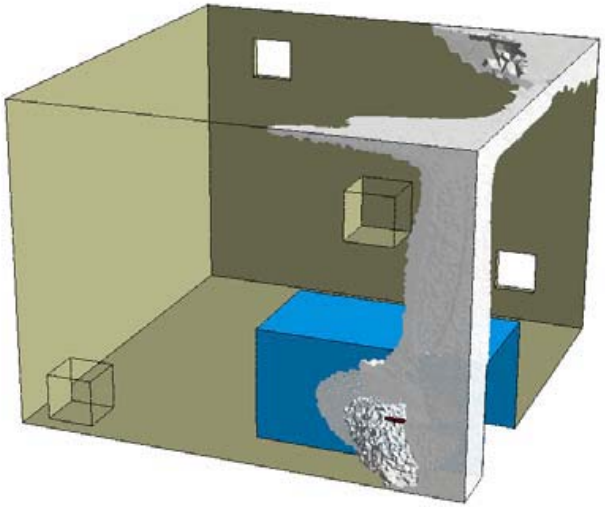
- Occupational exposure to contaminants

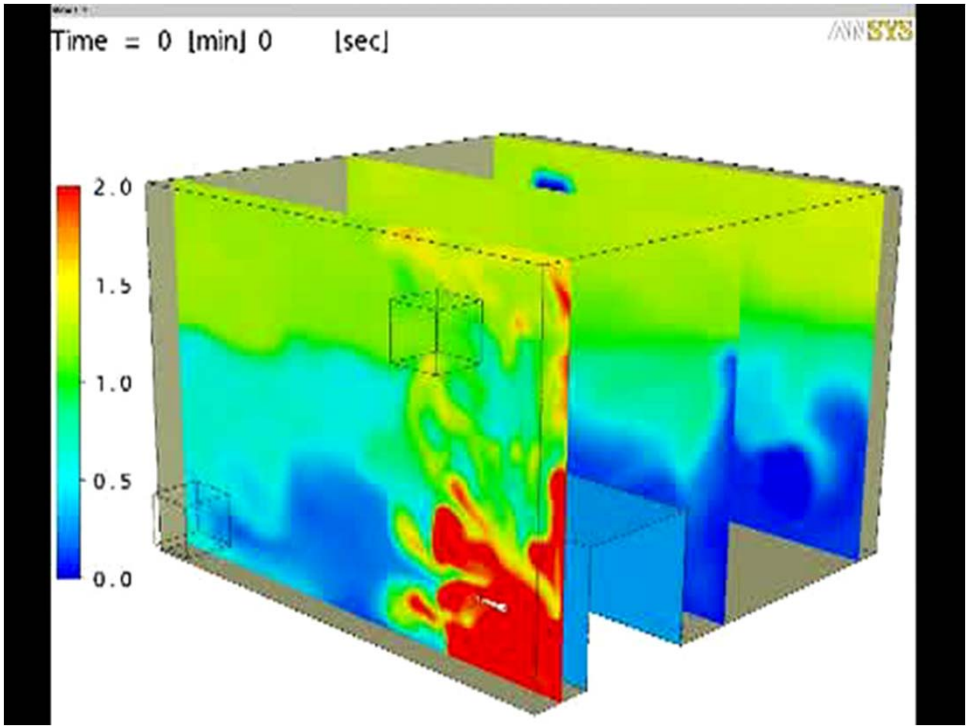


Experiments to demonstrate problems with general extract ventilation and identify need for LEV

Areas of Work

- Hazards from toxic/flammable releases





Experiments and CFD used to develop new guidance on area classification of low pressure natural gas releases

Areas of Work

- Incident Investigation: e.g. Buncefield

- 11 December 2005
- Storage tank over-filled during pipeline transfer
- 180 tonnes of petrol released over 23 minutes
- Vapour cloud approx. 500m × 400m × 2 m high
- Cost of damage from explosion and fire estimated at €1.2 billion

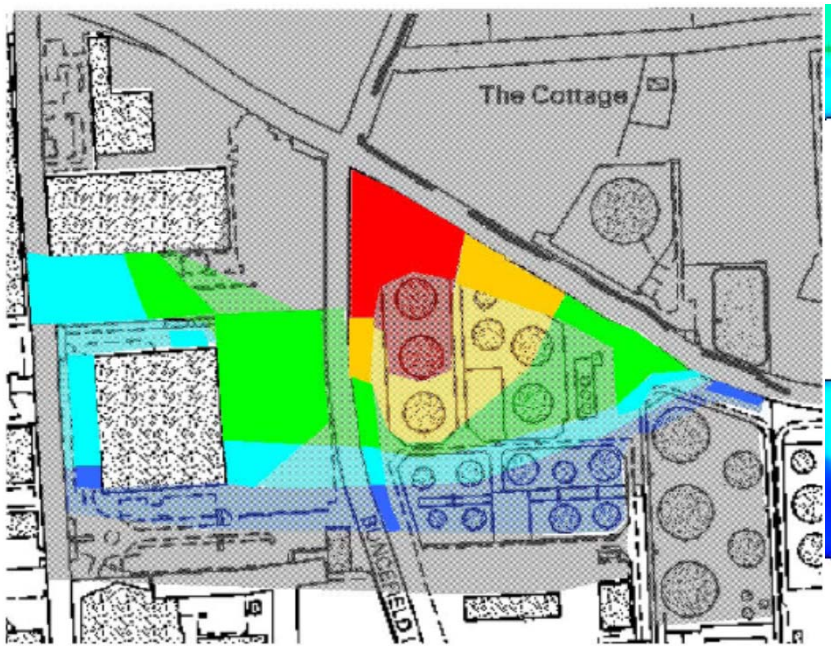
Areas of Work

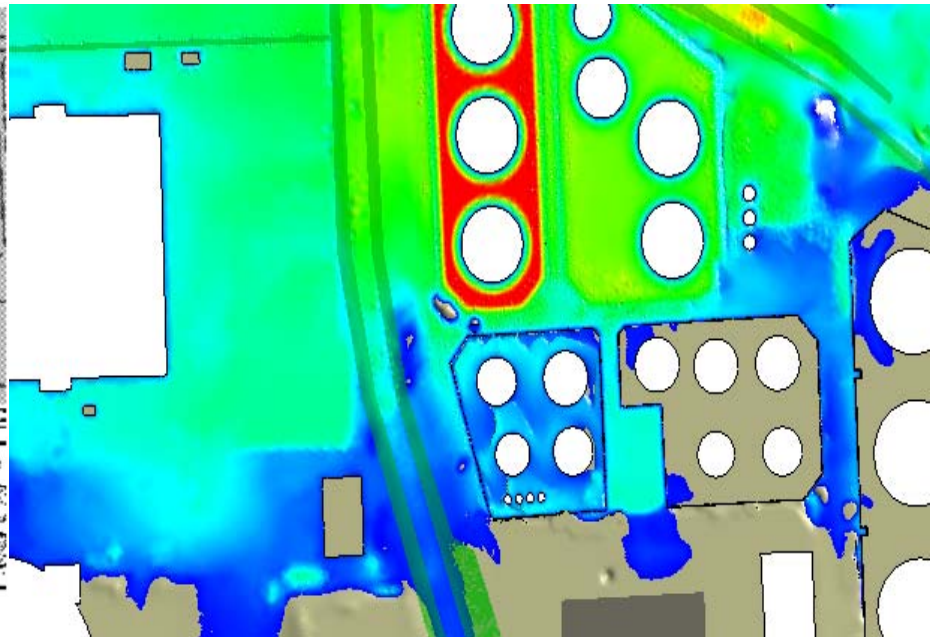
- Incident: Buncefield explosion

- Explosion registered 2.4 on Richter scale

Reasons for work

- Incident: Buncefield dispersion CFD

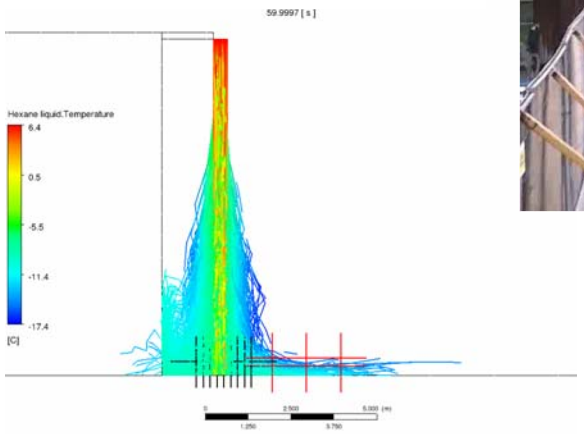




- How far did the cloud spread?
- How did the damage correlate to cloud depth?
- What are suitable inputs for explosion models?

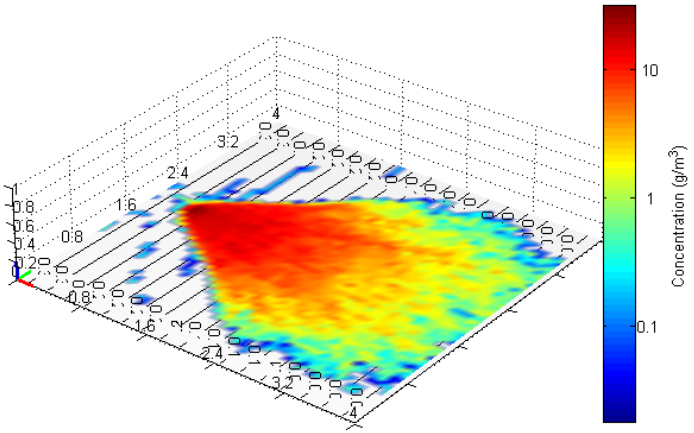
Reasons for work

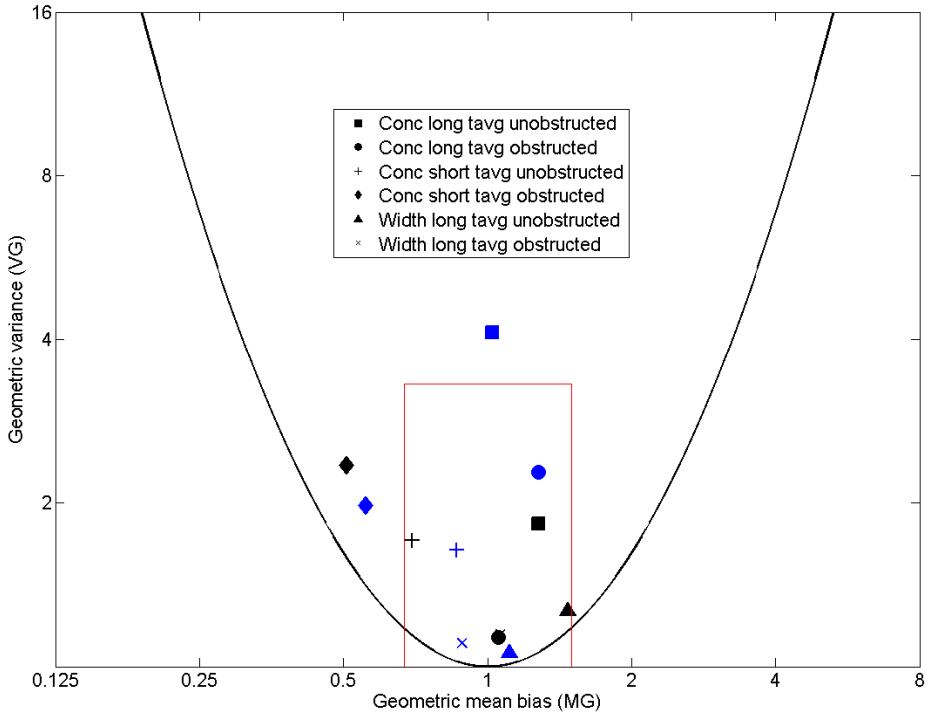
- Research: determine source from tank overfilling releases



Reasons for work

- Support: dense gas dispersion model evaluation





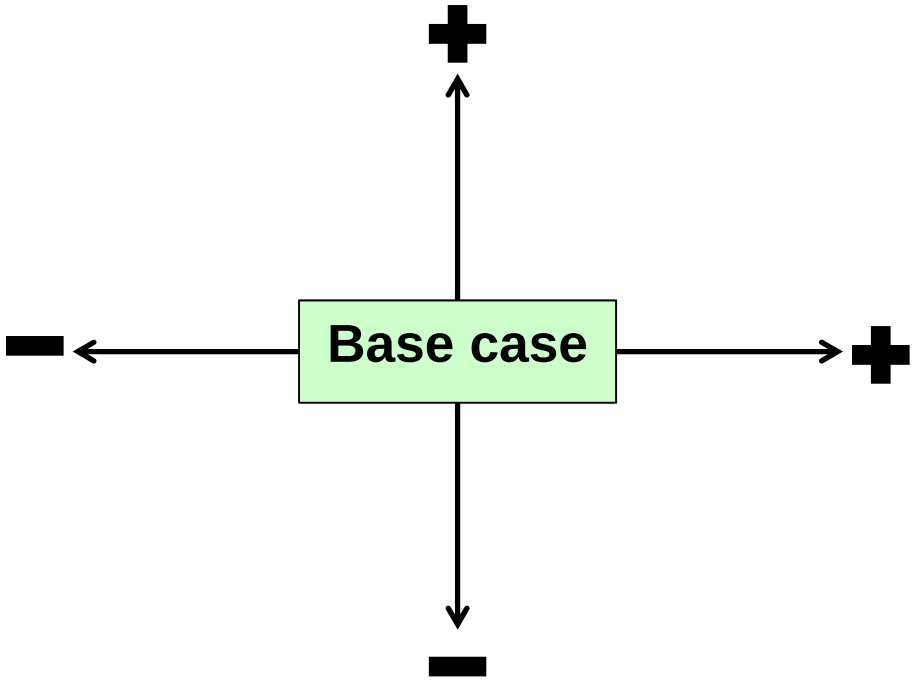
$$MG = \exp\left\langle \log_e\left(\frac{C_m}{C_p}\right)\right\rangle \qquad VG = \exp\left\langle \left[\log_e\left(\frac{C_m}{C_p}\right)\right]^2\right\rangle$$

Uncertainty analysis

- One at a time
- Toxicology
- Consequence modelling
- Nuclear

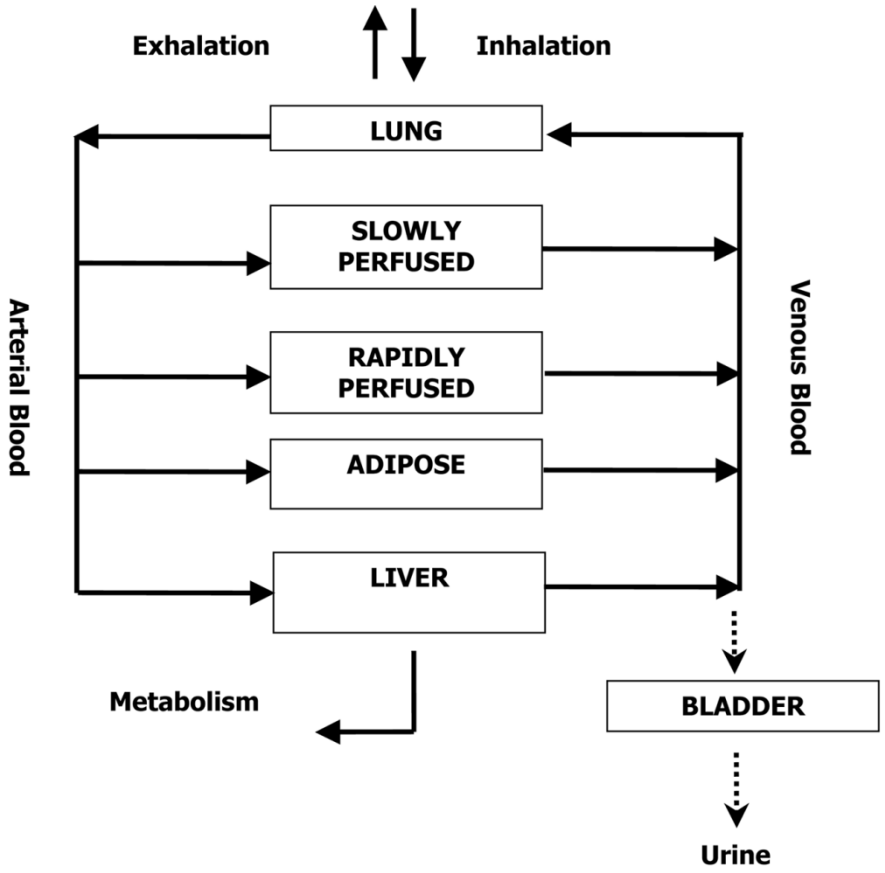
One at a time

- Local sensitivity analysis



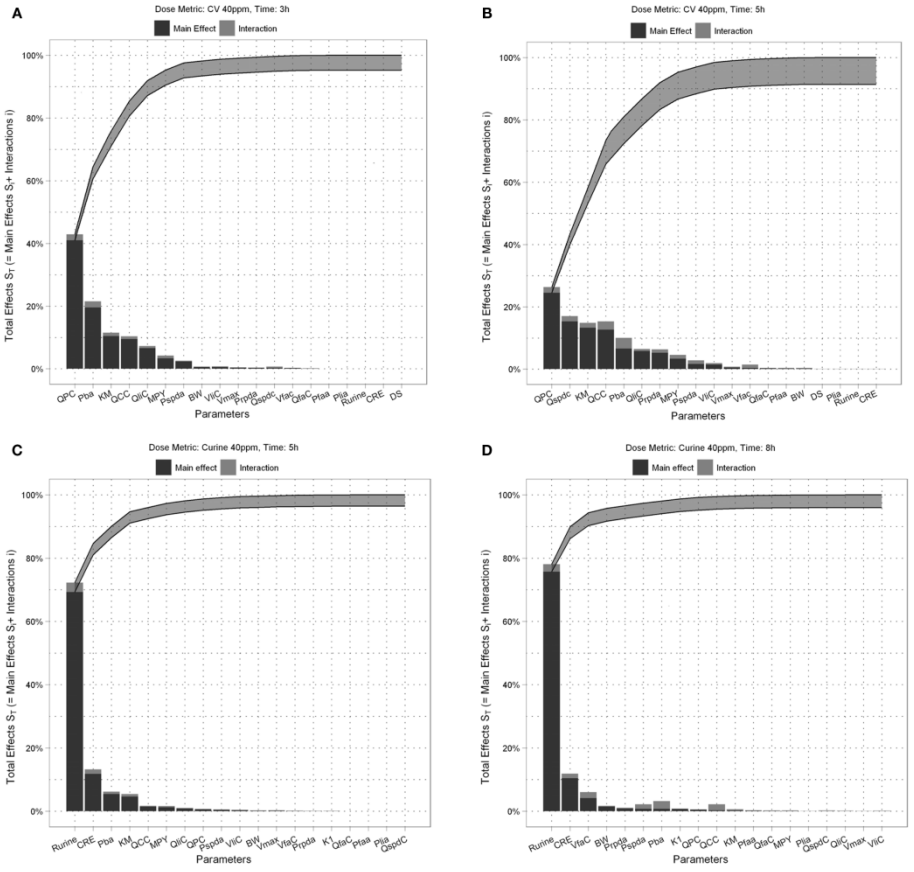
Toxicology

- Physiologically based pharmacokinetic (PBPK)
- Global sensitivity analysis



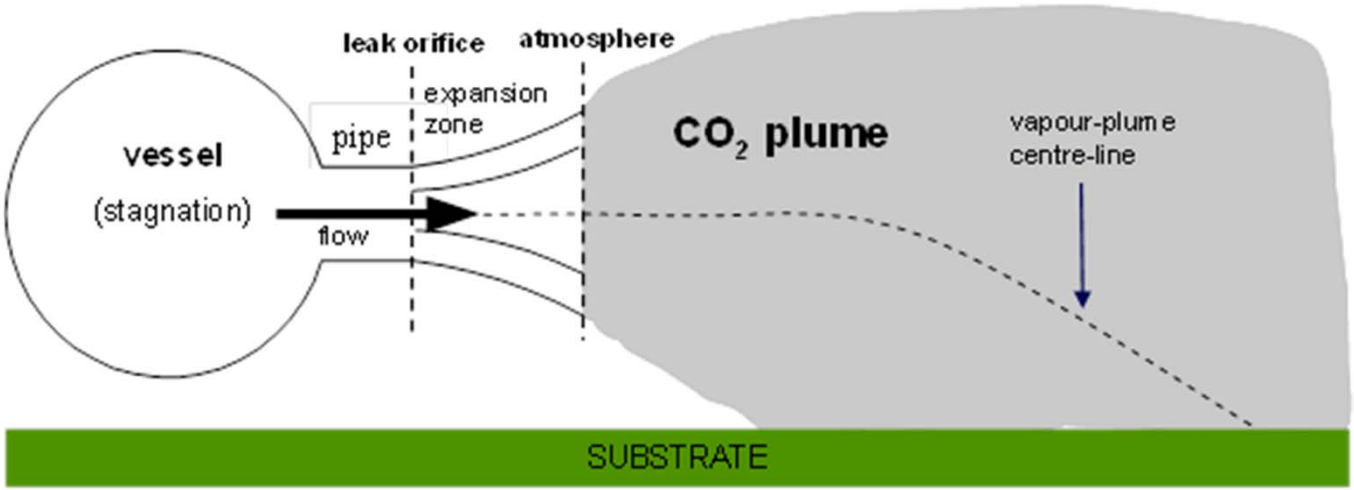
Toxicology

- Morris test (screening)
- eFAST (variance based, main and total effects)



Consequence modelling

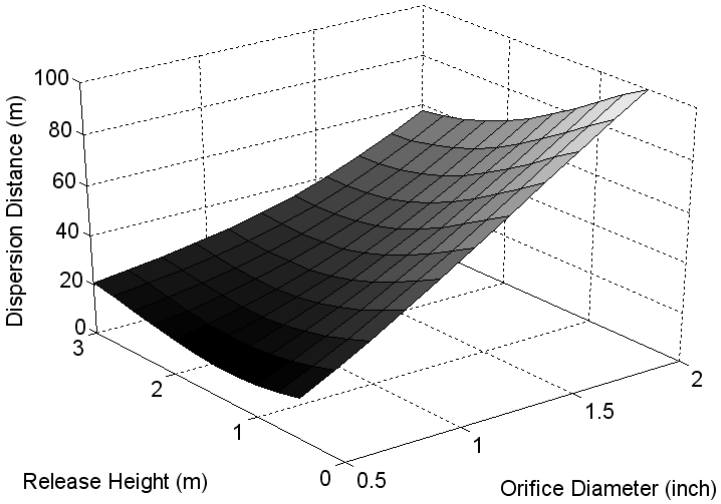
- Phast, DNV
- Integral model



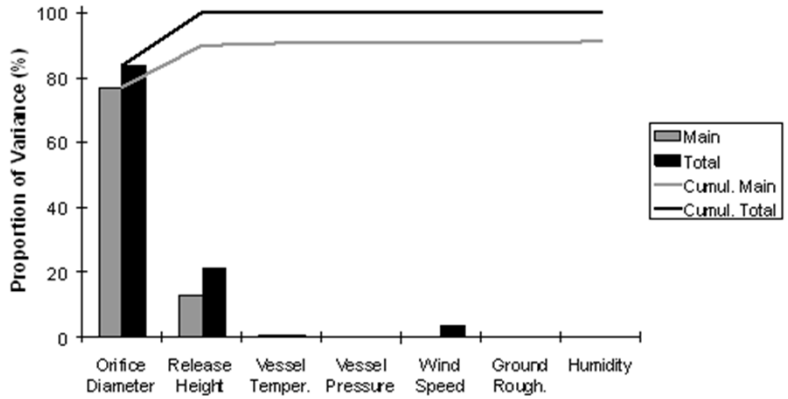
- Global sensitivity analysis
- GEM (Gaussian Emulation Machine)

Consequence modelling

- Mean, main effects and interactions



- Variance, main and total effects

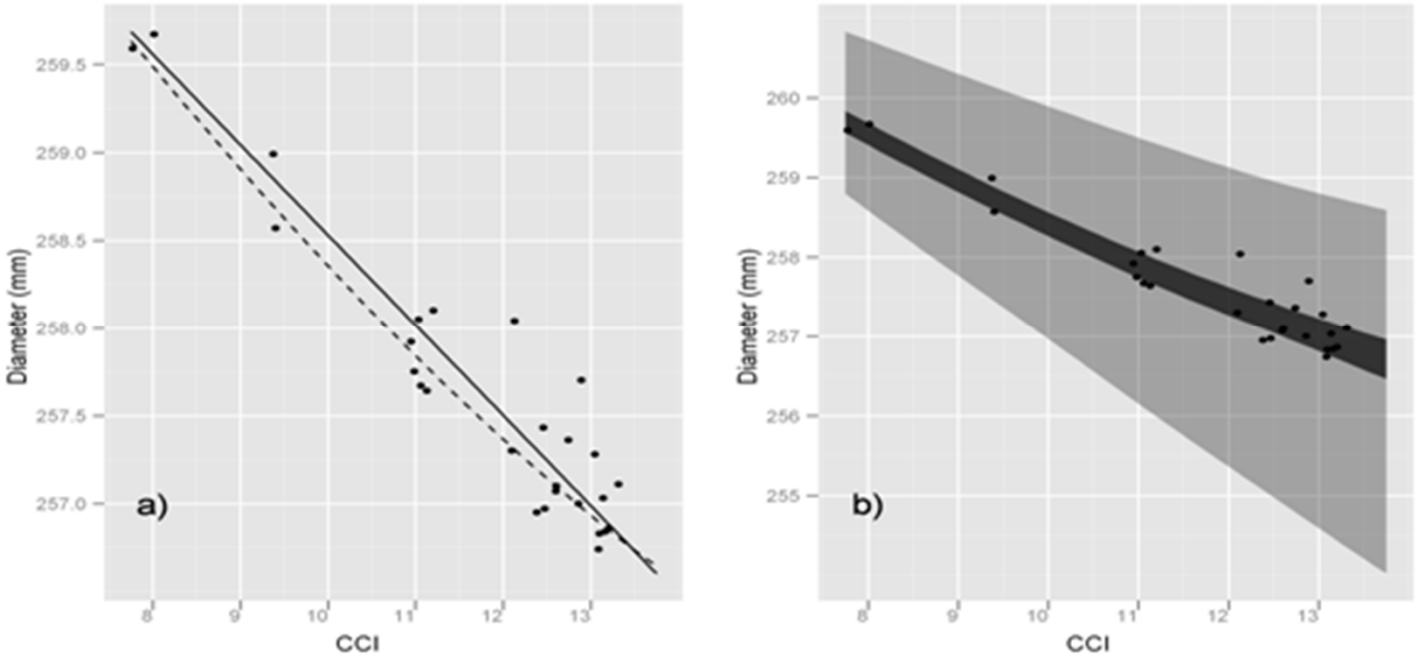


Nuclear

- Graphite moderator brick cracking
- Graphite bricks are also structural core components
- Finite Element Analysis model of brick cracking
- Bayesian emulator
- Calibration and Global sensitivity analysis

Nuclear

- Sensitivity analysis,
  - important calibration parameters
- Calibration

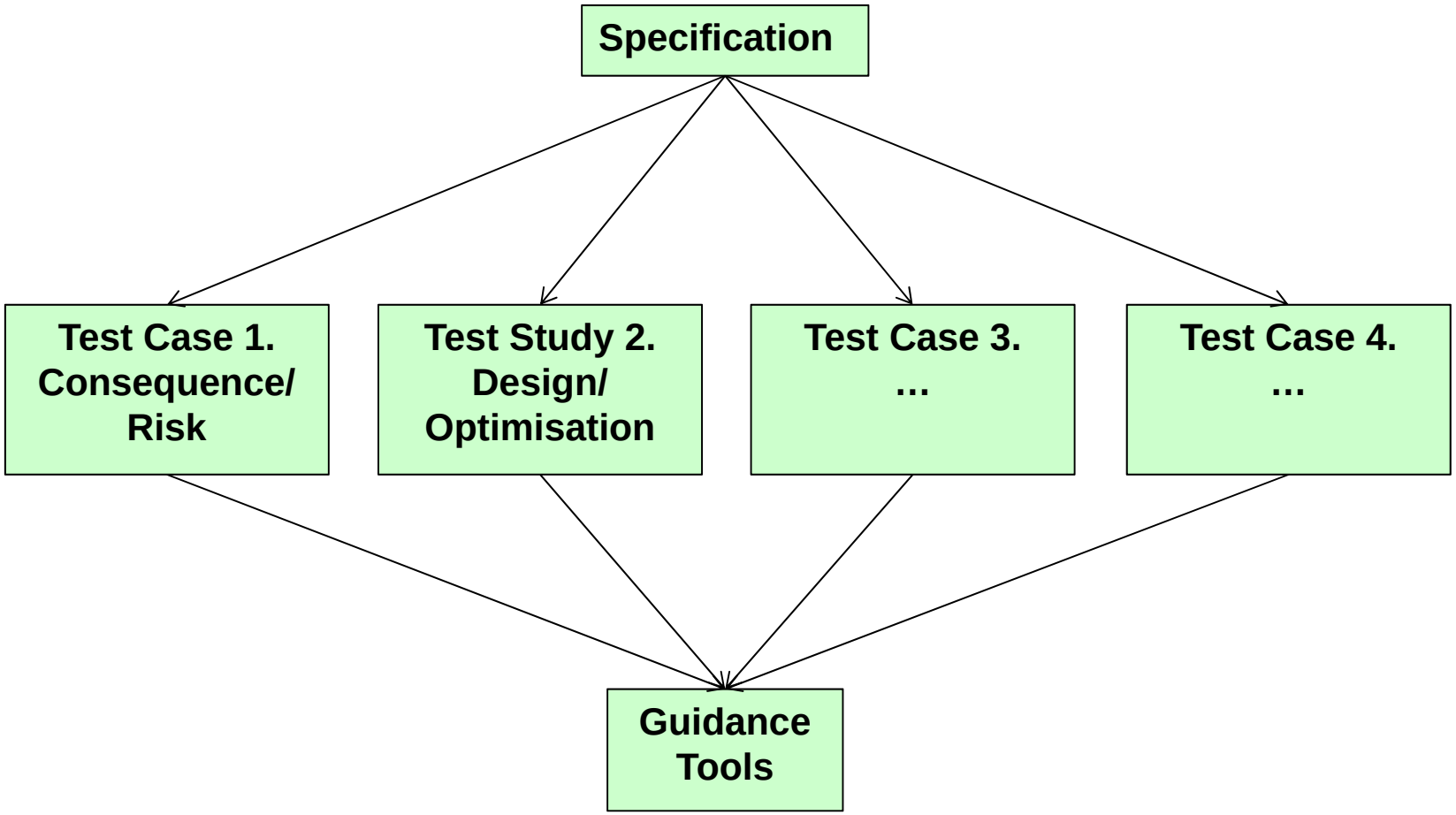


Analysis performed

	Analysis	Model uncertainty	BC uncertainty	Propagation	
				Approach	Invasive
One at a time	Local sensitivity	Yes	Yes	Simulator	No
Toxicology	Global sensitivity	Yes	?	Simulator	No
Consequence	Global sensitivity	?	Yes	Emulator	No
Nuclear	Calibration Global sensitivity	Yes	Yes	Emulator	No

	What we can do	To do
Sensitivity	Identification of important parameters	Probabilistic SA Switches Discontinuities
Uncertainty		95th percentiles Outputs in terms of inputs
Validation	Validate against measurements	Effect and representation of uncertainties on quantities of interest
Calibration	Calibrate an expensive model using emulators	

- Non-invasive
- Gaussian emulators
  - GEM (GEM-2)
- Available
- Practical


Specification
Test Case 1. Consequence/ Risk
Test Study 2. Design/ Optimisation
Test Case 3. …
Test Case 4. …
Guidance Tools

Consequence Test Case

- Thorney Island trials: dense gas dispersion
  - Field scale experiments
  - Wind-tunnel experiments (multiple repeats)
- Dispersion models (Phast, CFD, DNS?)
- BC uncertainties, Propagation