FIELD AND WIND TUNNEL EVALUATION OF CFD MODEL PREDICTIONS OF LOCAL DISPERSION FROM AN AREA SOURCE ON A COMPLEX INDUSTRIAL SITE

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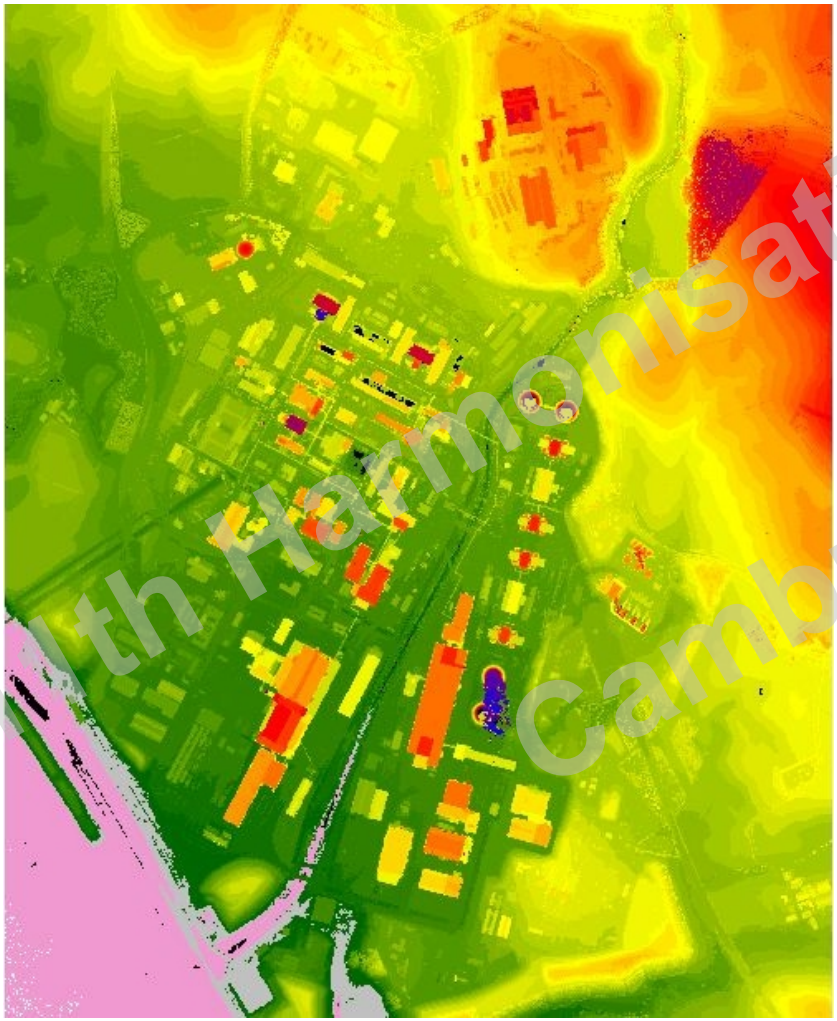
Introduction: the BNFL Sellafield site

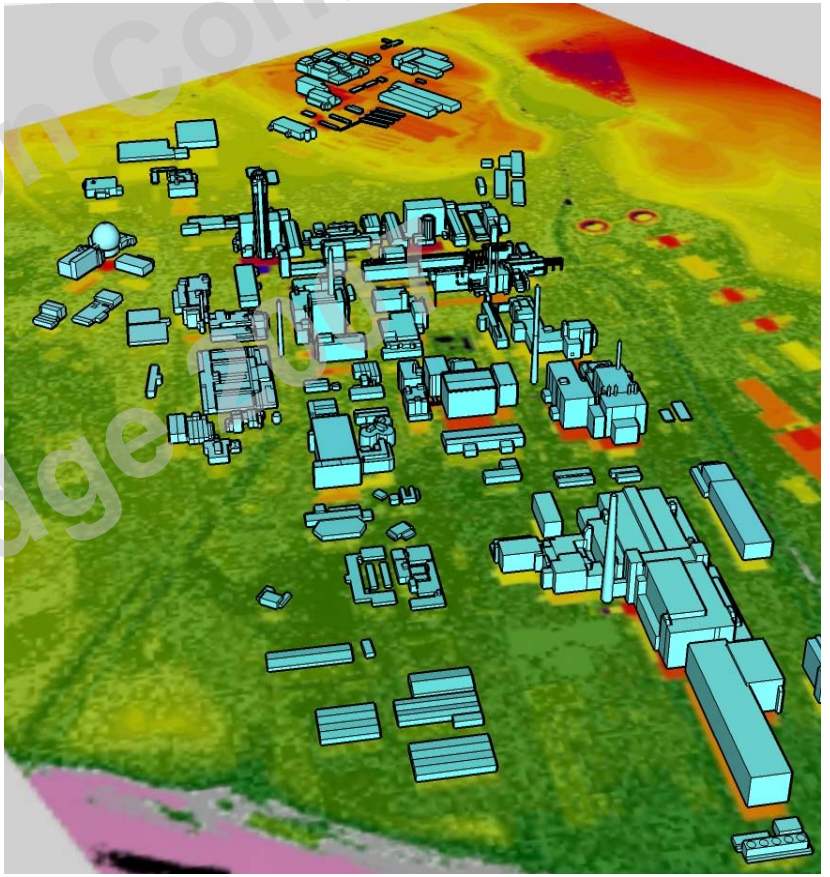
- Complex nuclear industry site
- Atmospheric emissions from multiple discharge points
  - scheduled release sources
  - fugitive sources
- Scheduled releases from stacks
  - range of stack heights
- Fugitive emissions more difficult to determine
  - mixing of scheduled releases and fugitive emissions
  - building effects

Modelling of the Sellafield site: sizing the buildings and terrain

Aerial LIDAR survey of the Sellafield site and surroundings.



Analysis of LIDAR data yields building dimensions, allowing virtual models of Sellafield to be constructed.

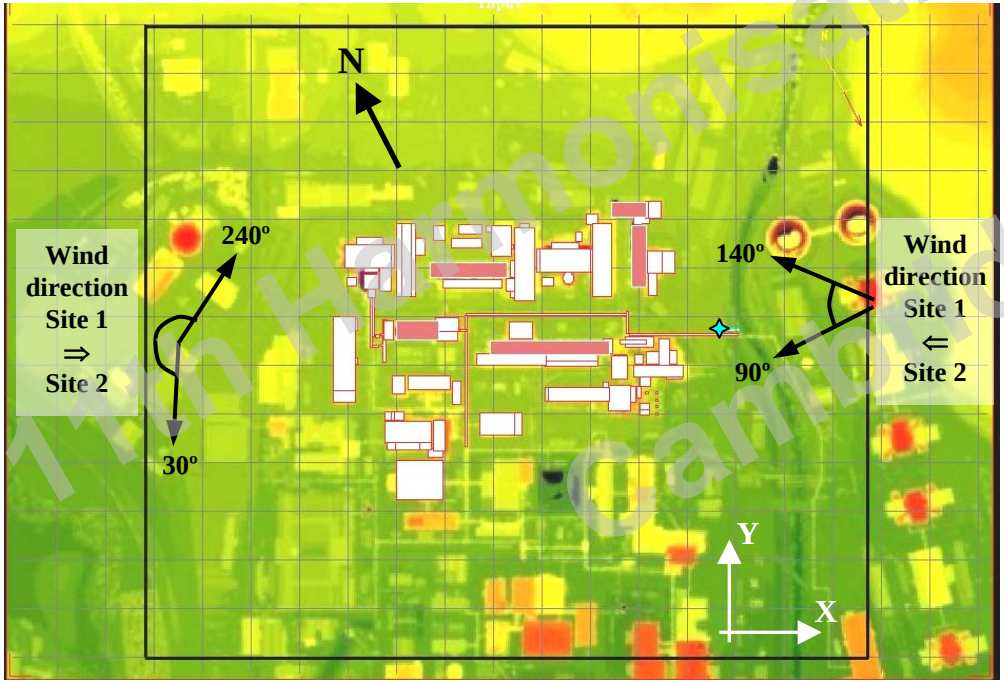


* Building dimensions thus obtained are used to generate terrain for advanced modelling.

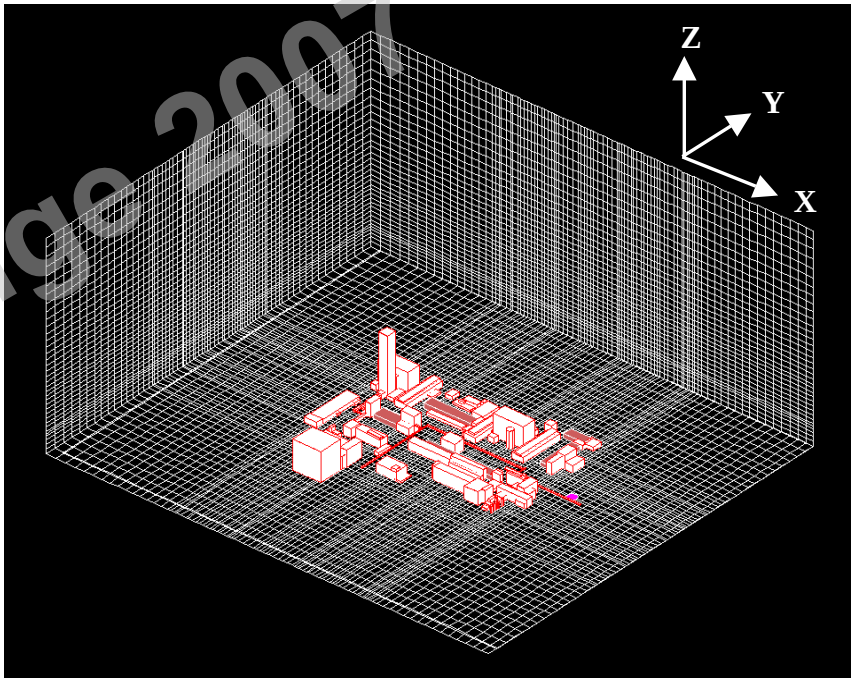
CFD modelling to calculate dispersion factors for area sources

CFD package Fluidyn-PANACHE-PANEIA was used to model fugitive emissions (designed for simulation of atmospheric flows and pollutant dispersion over short and medium ranges).

Background image (here from LIDAR survey) used to help generate computational domain.

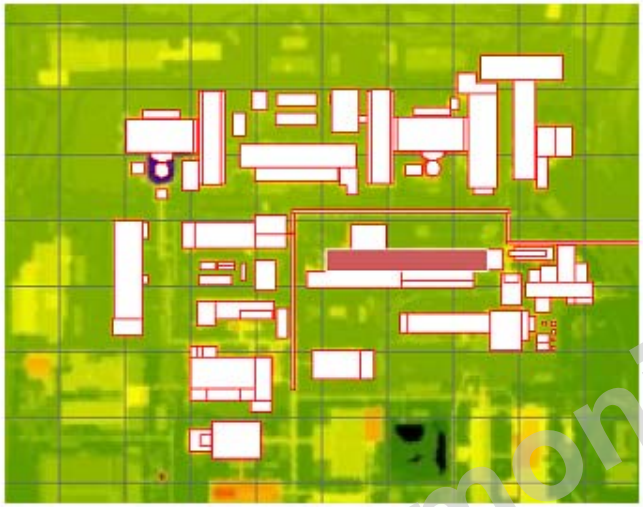


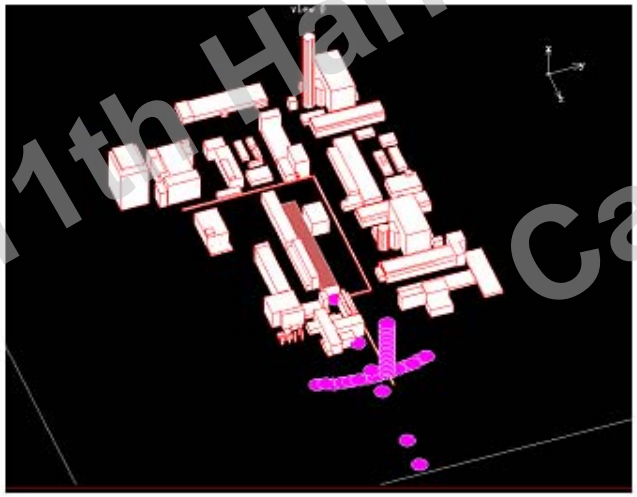
3-d orthogonal mesh mapped around buildings in left hand image



N.b. the background image has been rotated by 27° anticlockwise in order to align the buildings with the edges of the computational domain.

Sensitivity tests of the CFD code



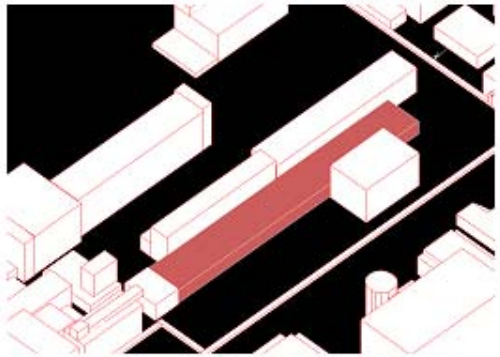


Simulations performed to test sensitivity of cfd code to input and user defined parameters.

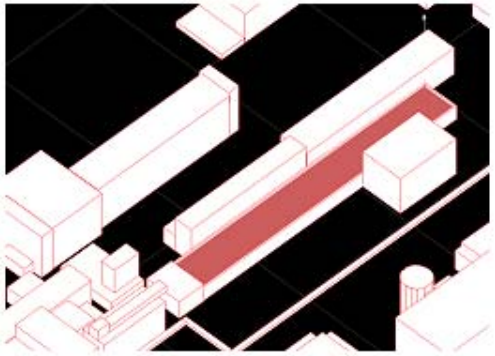
Define a baseline simulation, position monitoring locations in domain, then run code repeatedly, varying the following one at a time.

- Grid fineness
- Time step
- Ground roughness
- Numerical scheme
- Turbulence model
- Geometry

Simple Area source



Complex Area source



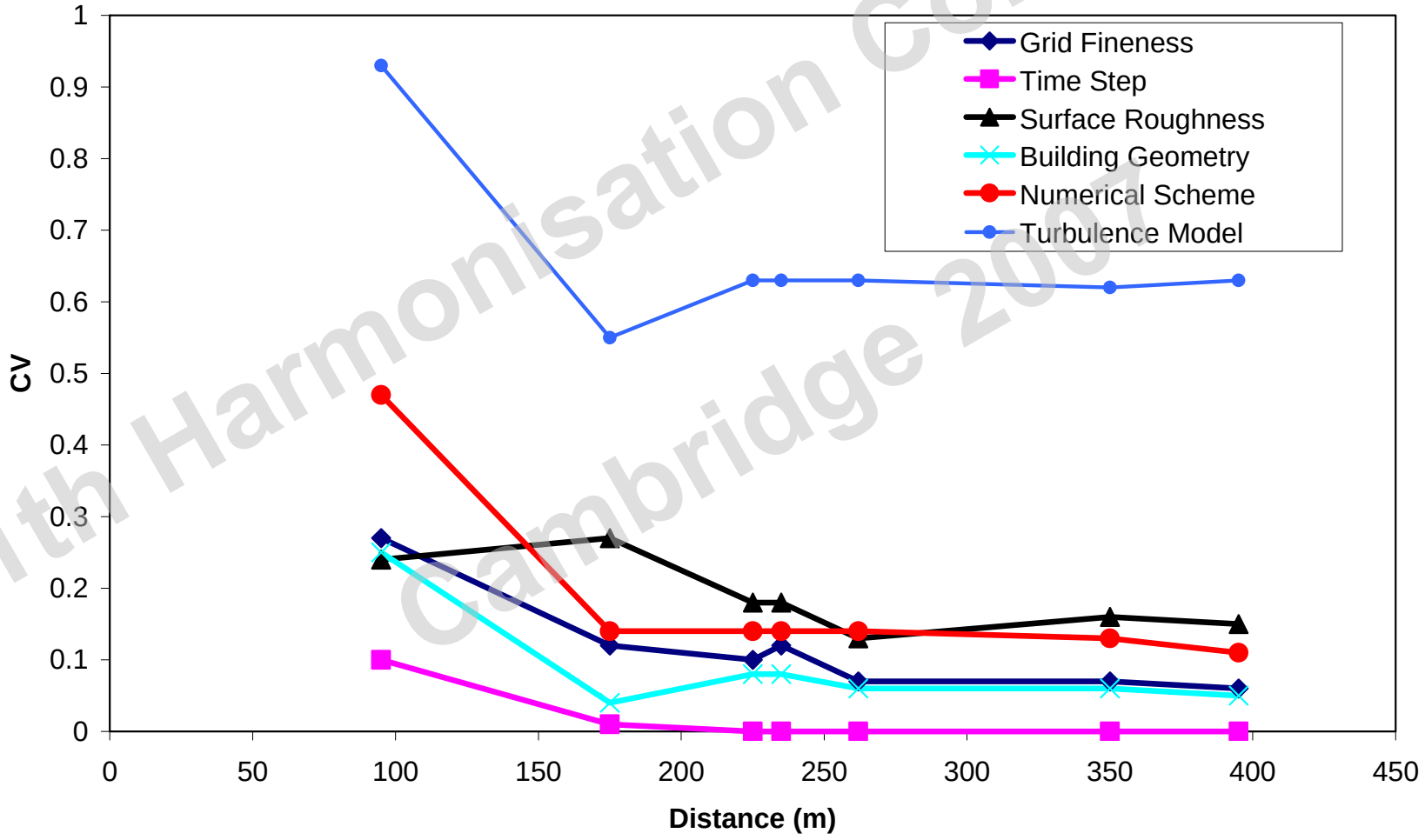
Sensitivity tests of the CFD code

SCHEDULE OF TESTS

Parameter	Grid Fineness (Cells)	Time Step (s)	Roughness Length (m)	Numerical Scheme	Turbulence model	Building Configuration
Baseline	69 × 61 × 24	0.2	0.5	1st order upwind	k-epsilon	Area source flush with building
Variations	74 × 68 × 29	0.1	0.1	1st order weighed upwind	k-diffusion	Recessed area source
	83 × 67 × 29		0.3	2nd order	k-L	Upwind building removed
	86 × 77 × 39		0.7			

Sensitivity tests of the CFD code

RESULTS



Comparison with meteorological data

Offsite Met. Station

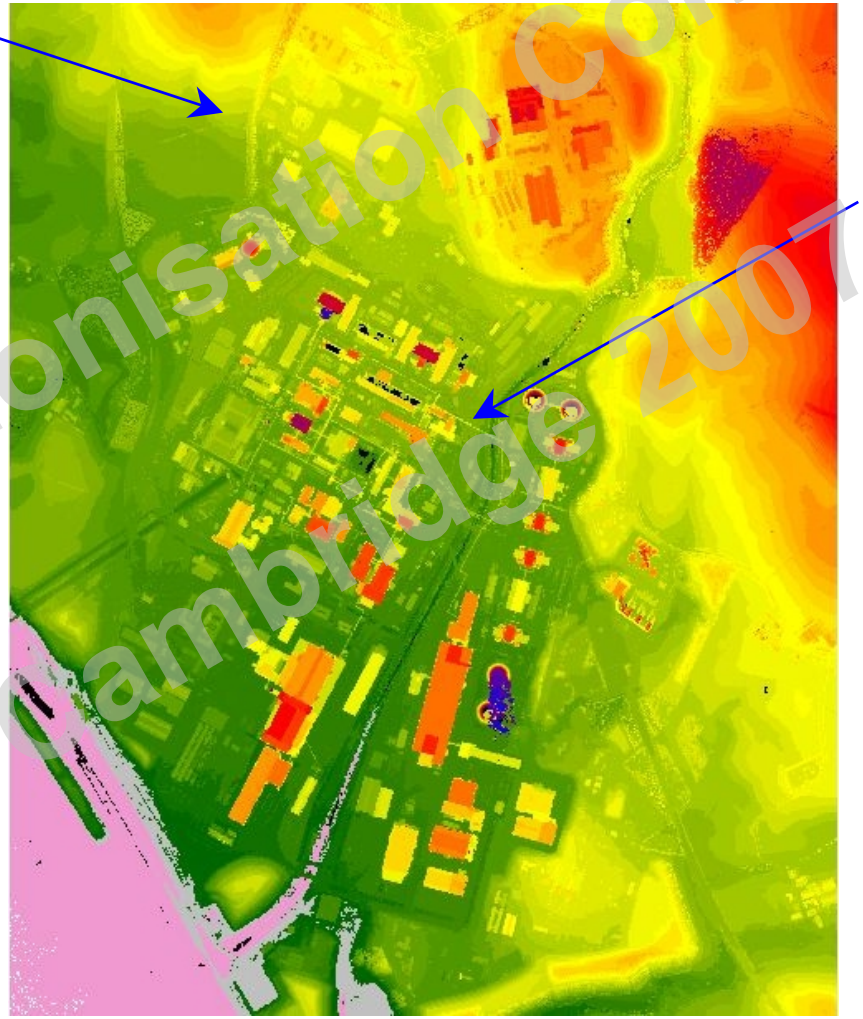
Site 1

Profiles of *U*, *T*, *Phi*

Pressure

Global Radiation

Rainfall



Onsite Met. Station

Site 2

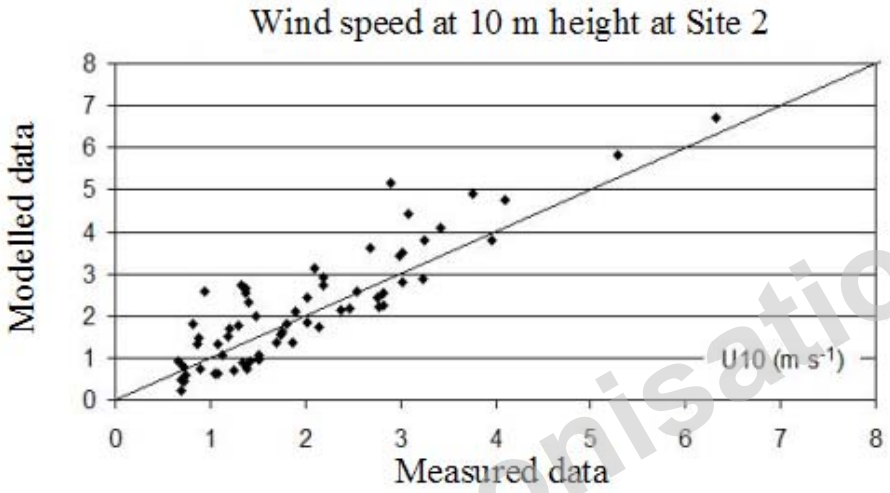
Sonic anemometer

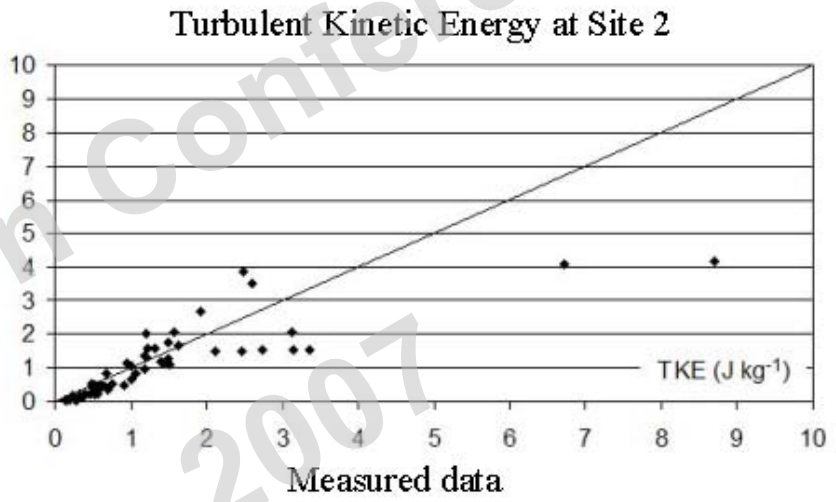
(5 Hz variances, co-variances, means)

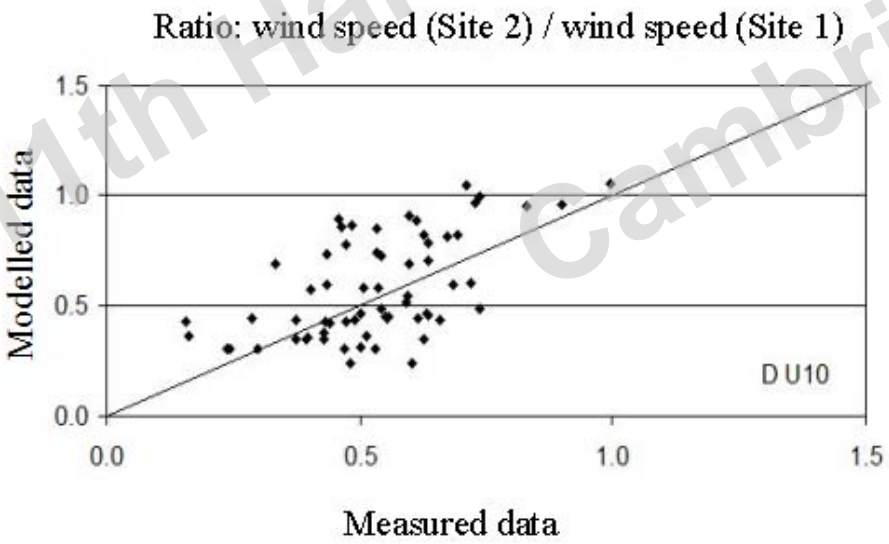
Conventional cup and vane

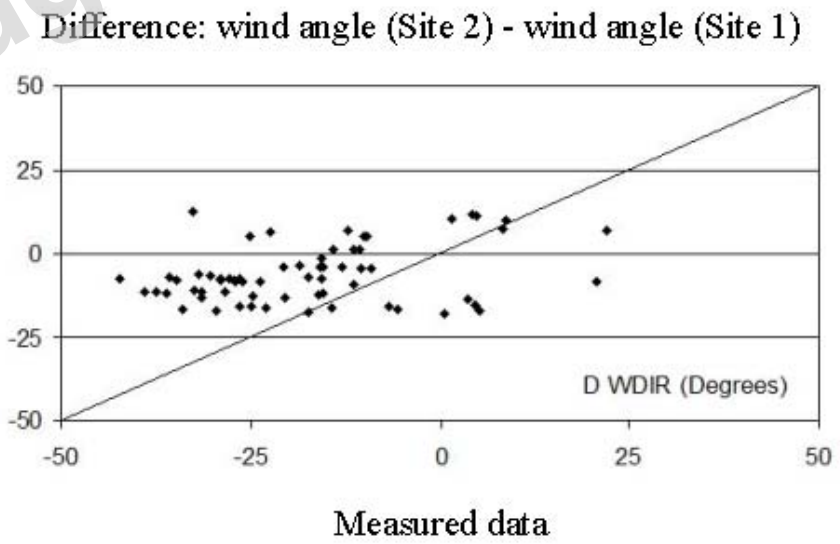
(means)

Comparison with meteorological data

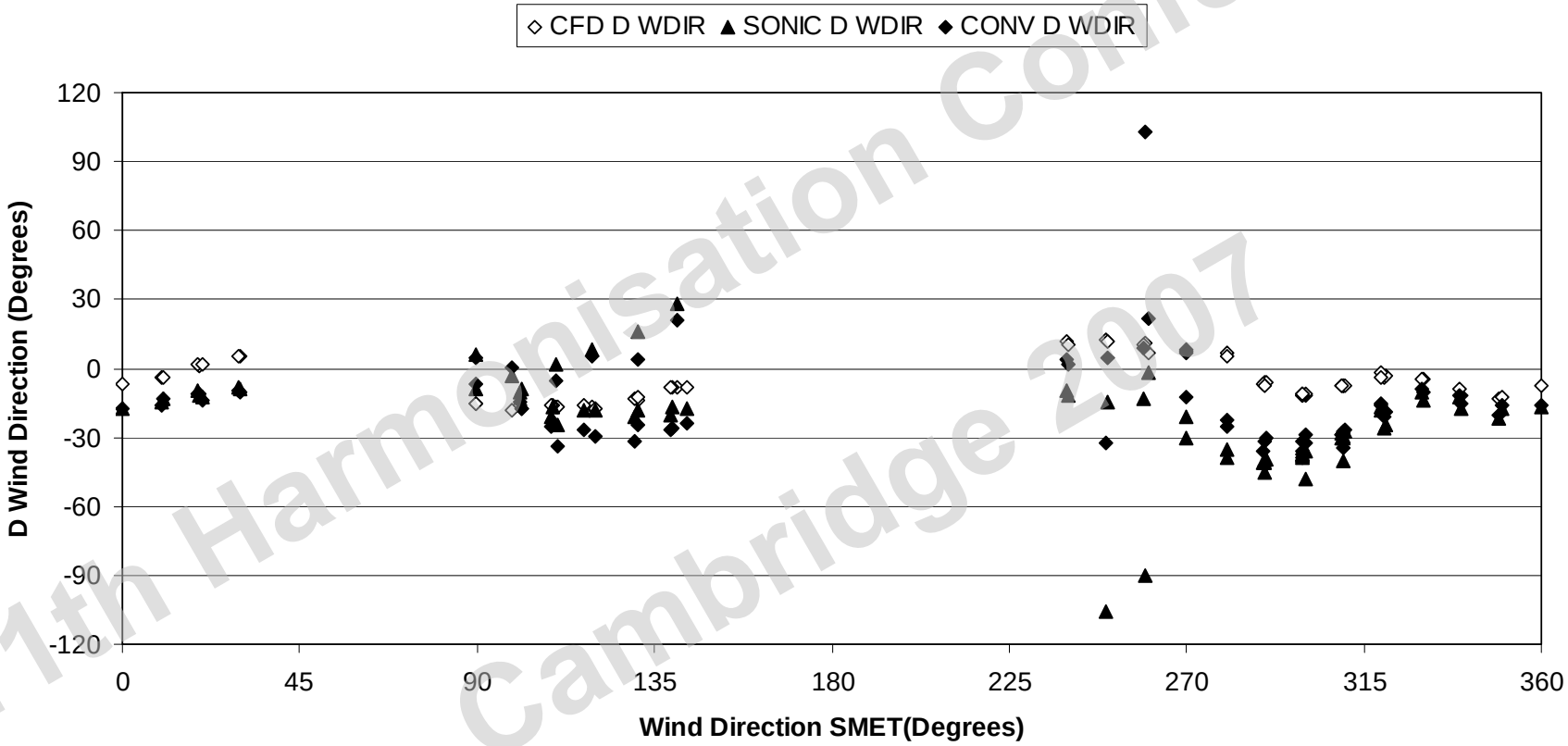








Comparison with meteorological data

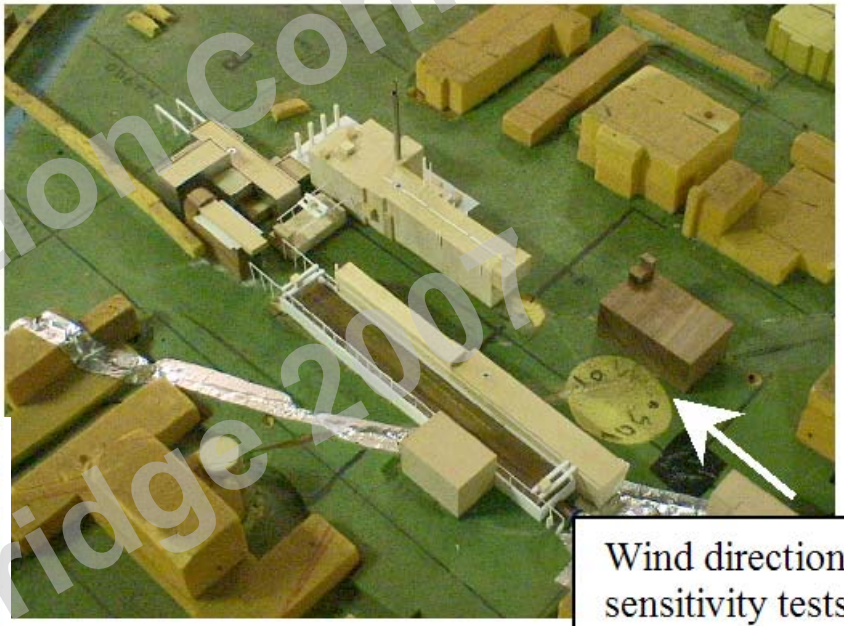


Wind tunnel testing of the CFD model

Wind tunnel testing performed using a 1:500 scale model of the Sellafield site.

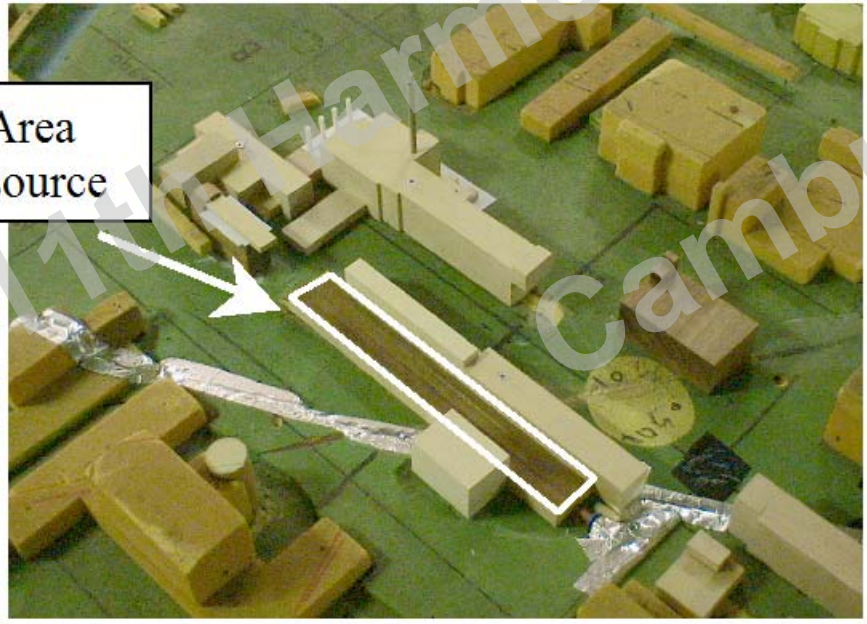
Simulation of an area release from the model pond were performed and results compared against CFD data

Highly-detailed versions of pond and adjacent buildings. (case DDD)



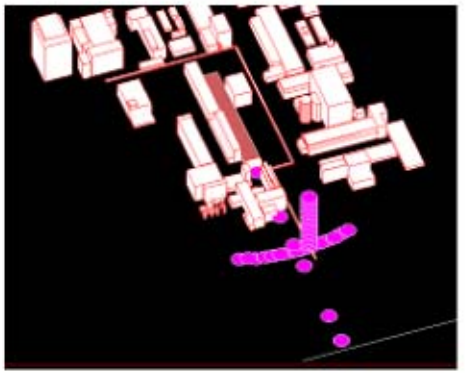
Wind direction for sensitivity tests

Simple versions of the pond and adjacent buildings.(case SSS)

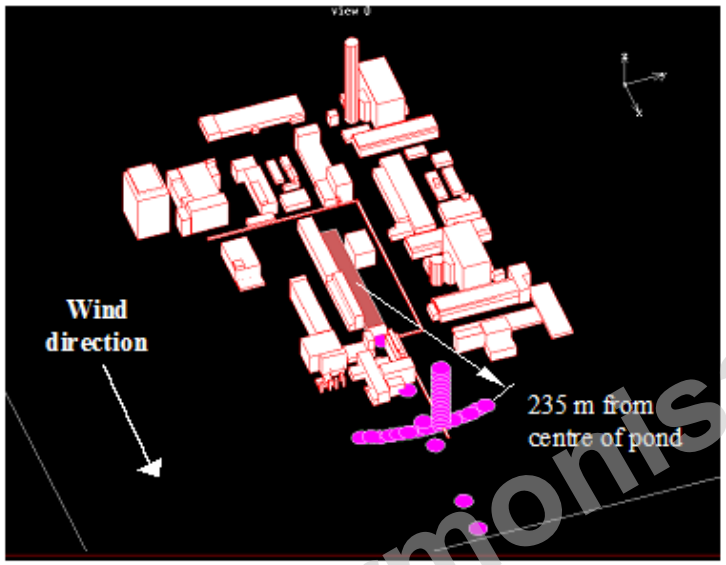


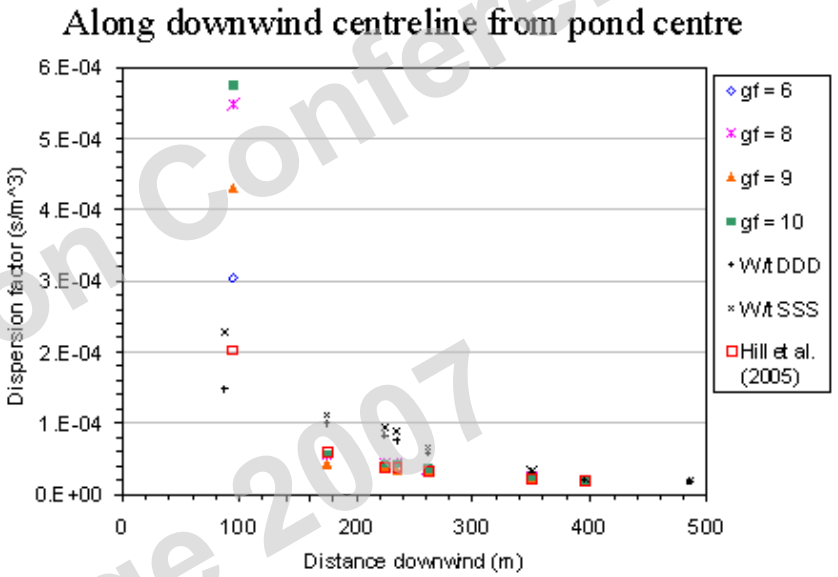
Area source

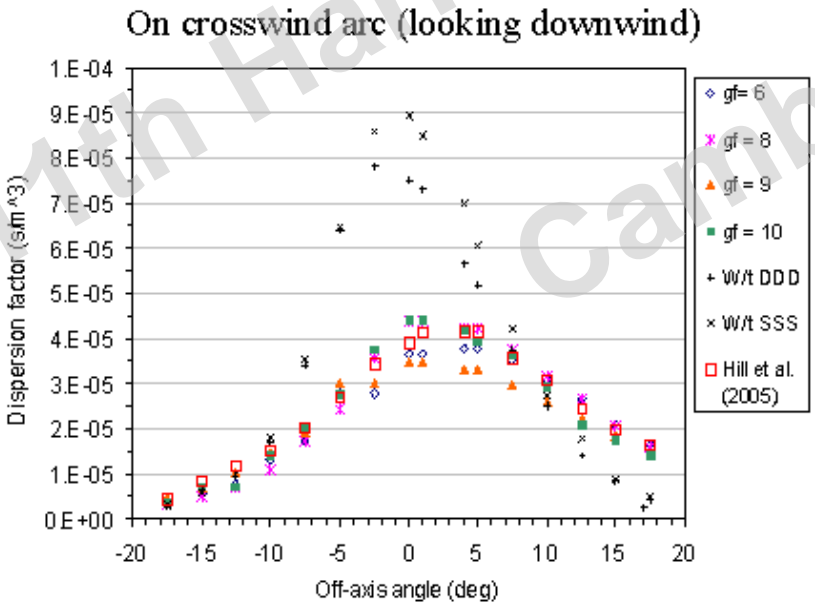
Wind tunnel measurements made at the same positions as the CFD monitor points (pink dots)

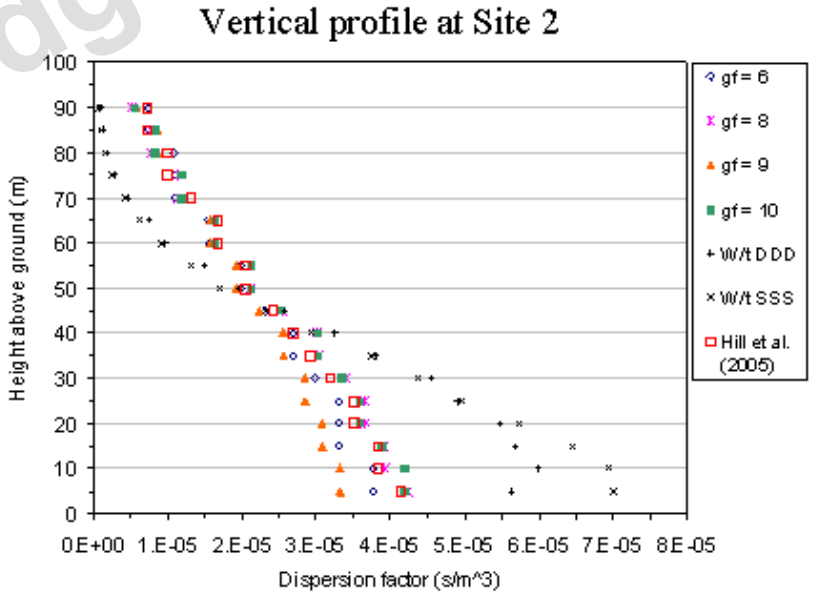


Comparison of wind tunnel and CFD results for varying grid fineness

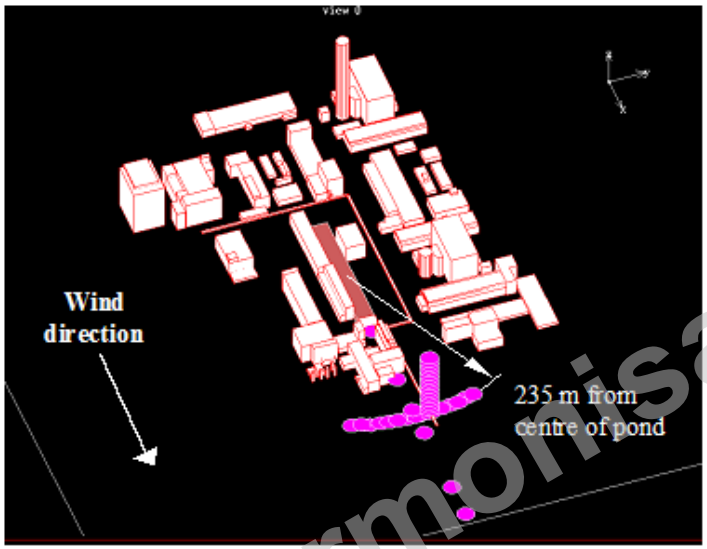


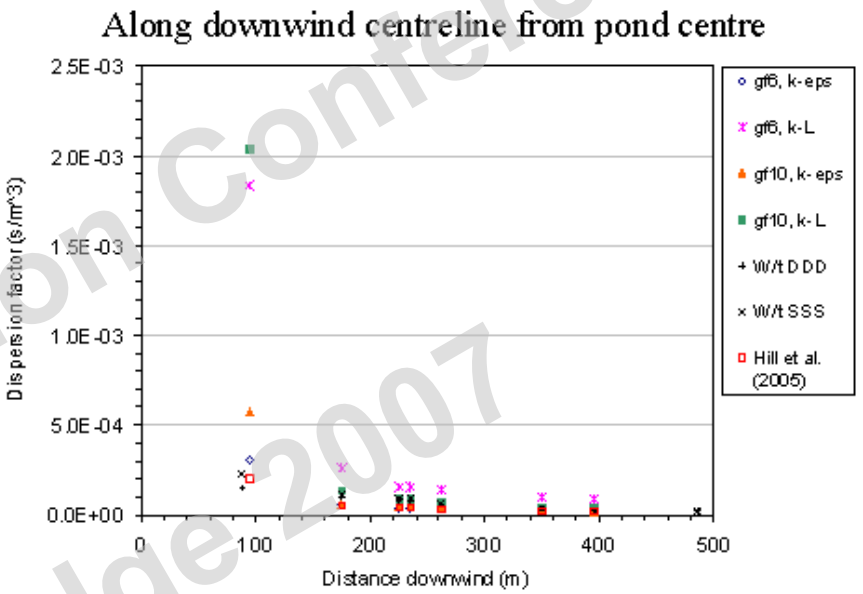


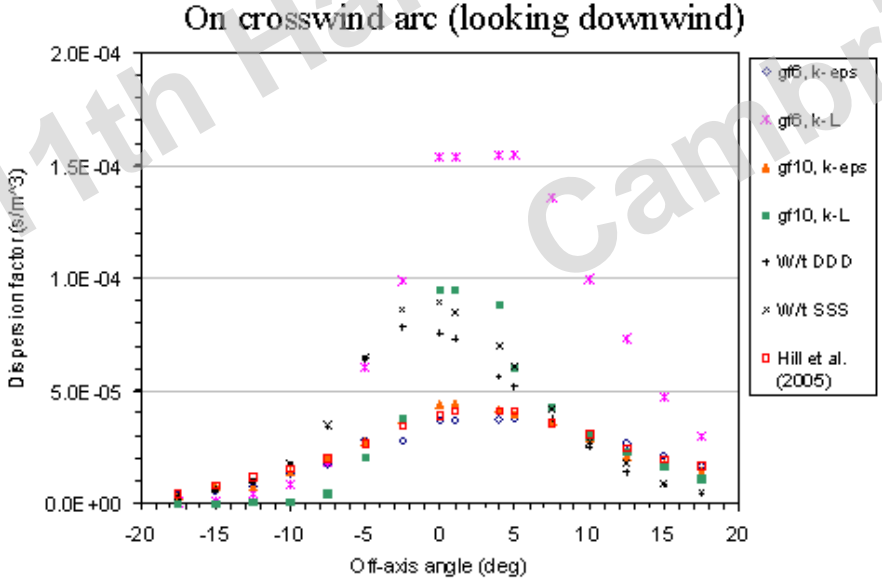


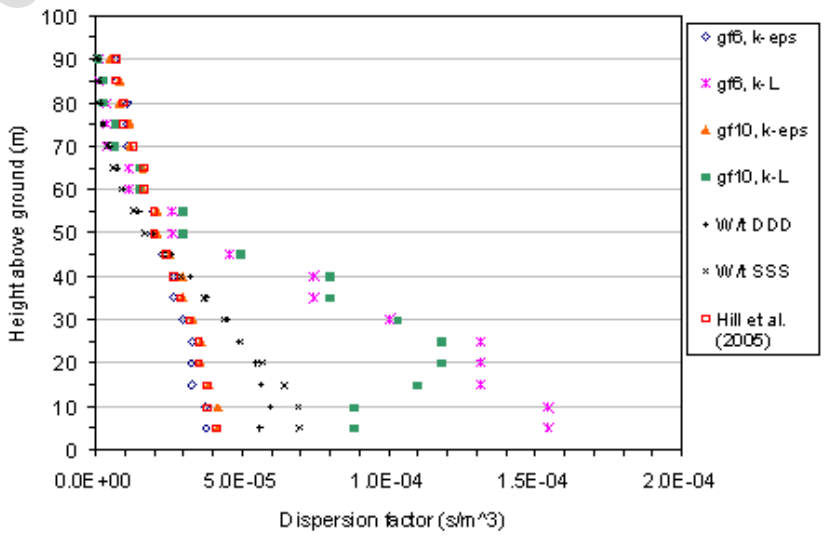


Comparison of wind tunnel and CFD results for turbulence models and values of grid fineness

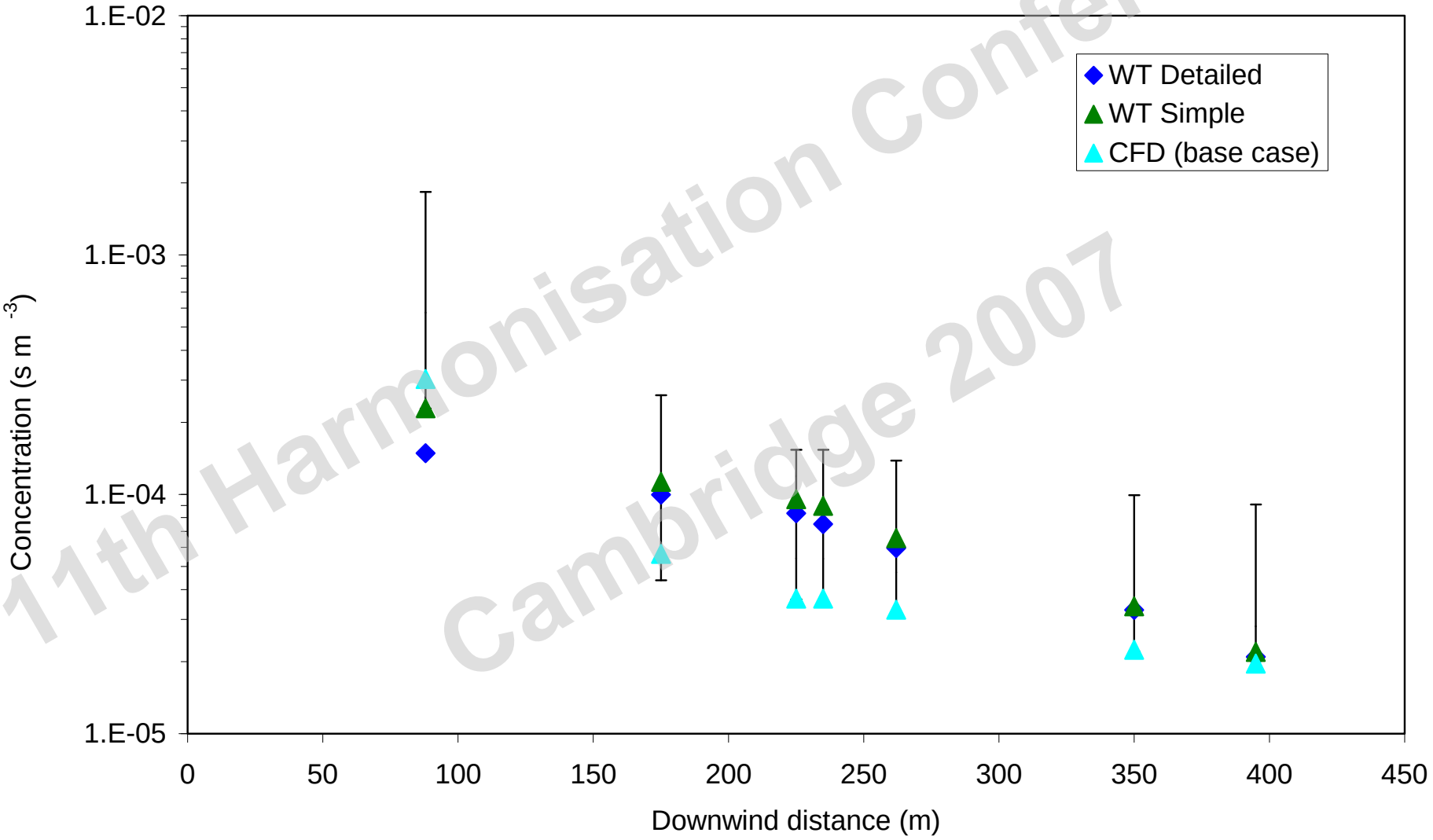








Validation of CFD modelling: Summary



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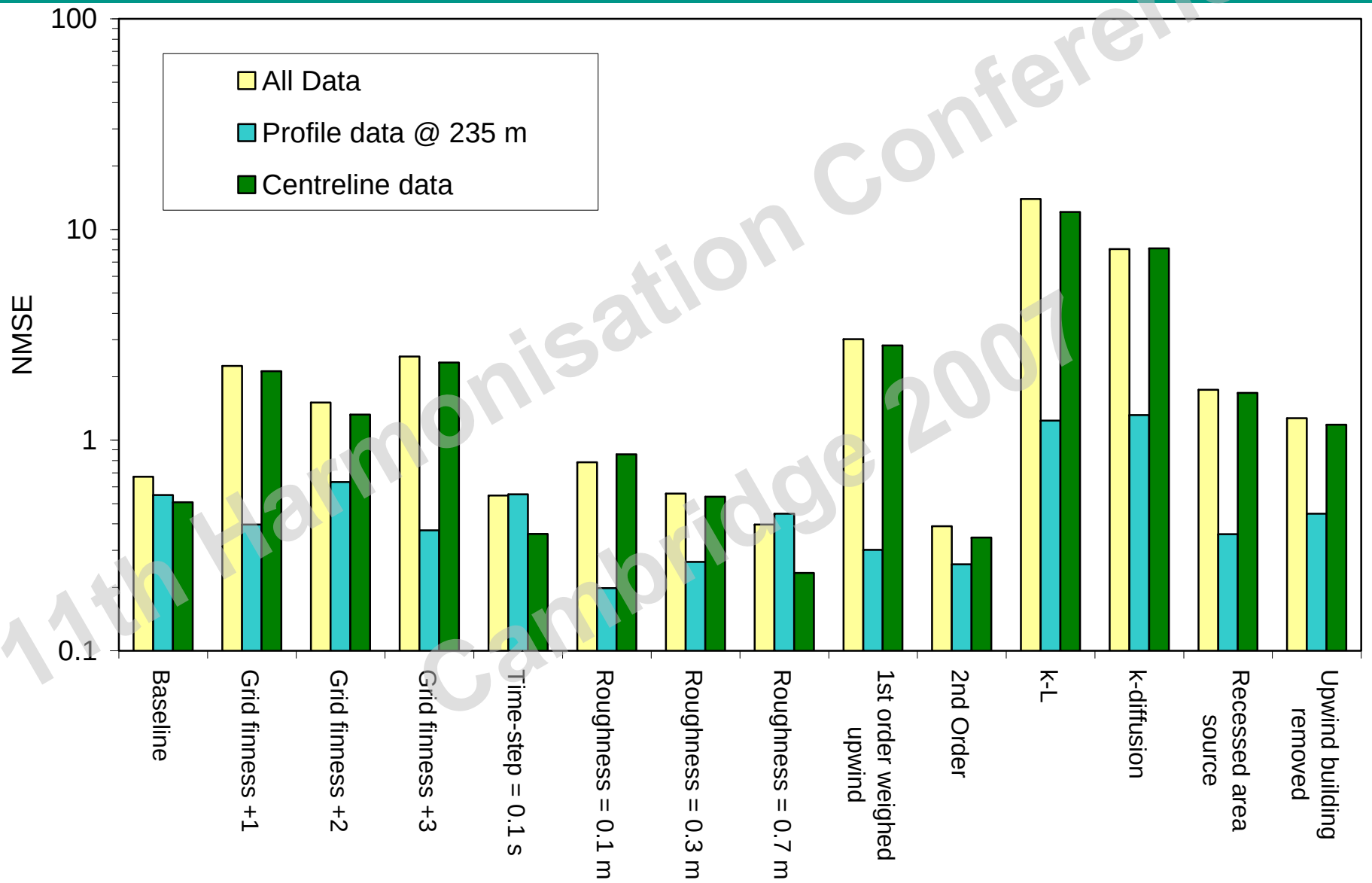

Conclusions

- The CFD model Fluidyn Panache was found to provide realistic estimates of on-site meteorology and atmospheric dispersion through comparisons with monitoring data and wind tunnel experiments.
- The concentrations predicted by the numerical model were found to be particularly sensitive (by more than a factor of 5) to the specification of turbulence model, with the k-epsilon model providing dispersion estimates that were closest to the wind tunnel data.
- Uncertainties in wind tunnel and numerical modelling of local dispersion from an area source on a complex site were found to be highest close to the source and to decline with distance from the source due to mixing of the plume.
- Consideration of detailed fine scale features in either model was only found to be necessary to estimate dispersion in the near-field (less than 100 m from the source in this study).

Acknowledgements

We would like to express our grateful thanks to

British Nuclear Group (Sellafield) Limited for funding this study

End