Statistics for street pollution modelling: Lab experiments & CFD calibration

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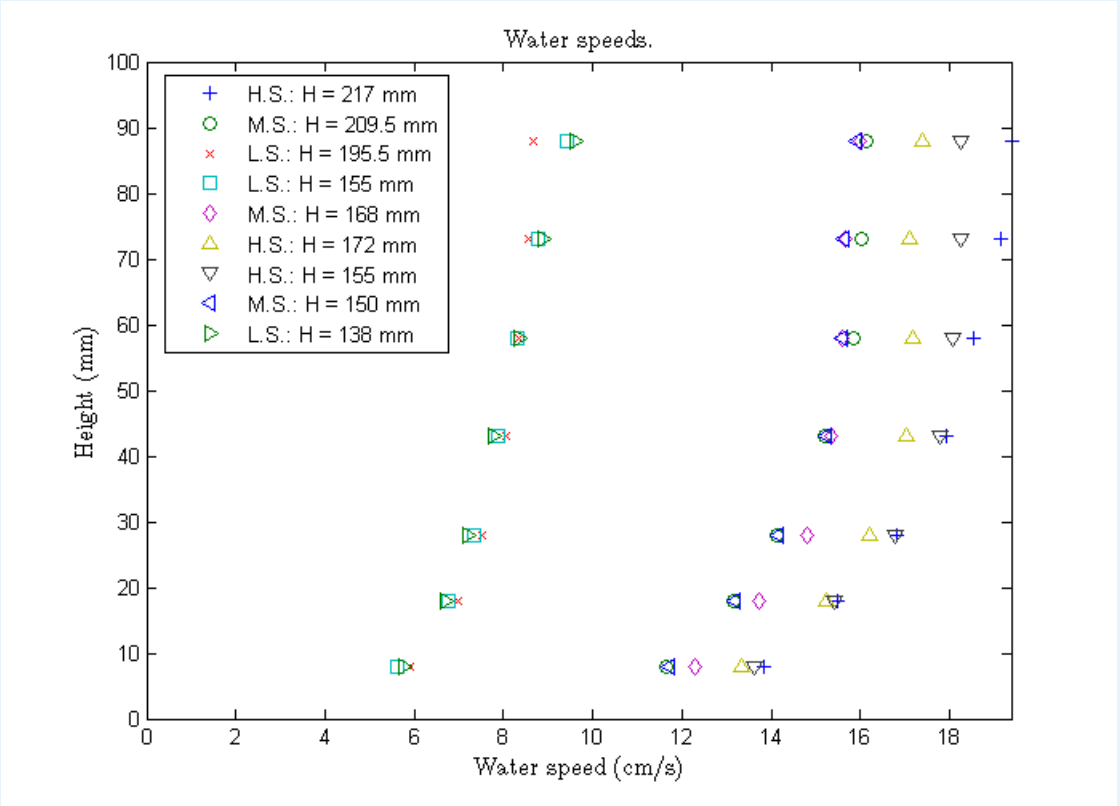
Water Tunnel experiments

1. understand the pollution in street canyons
2. lab experiments in a water tunnel, speed flows
3. speed meters locations issue
4. validation of locations
5. CFD modelisation (on-going!)



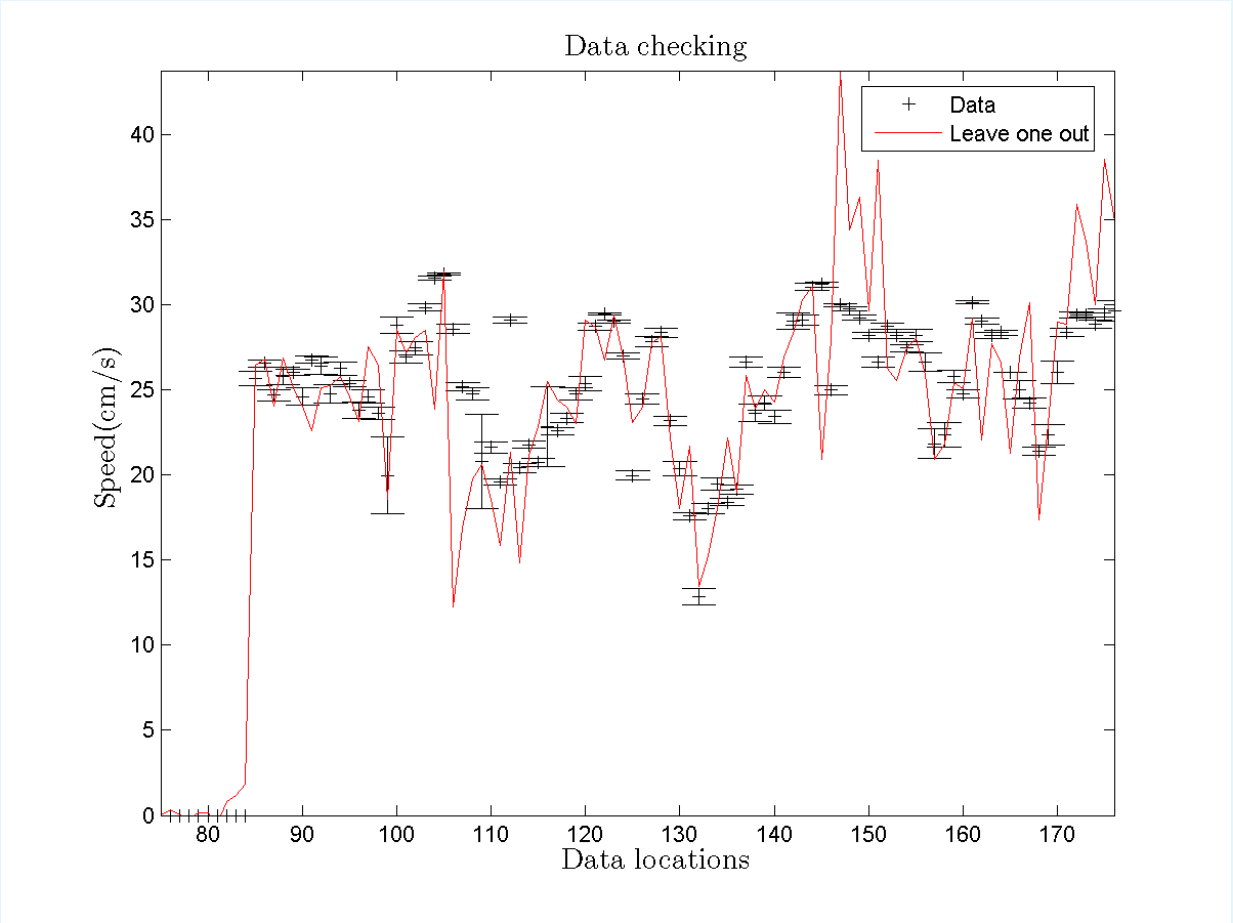
Speed vertical profiles along the water tunnel initially considered.

High speed was selected.

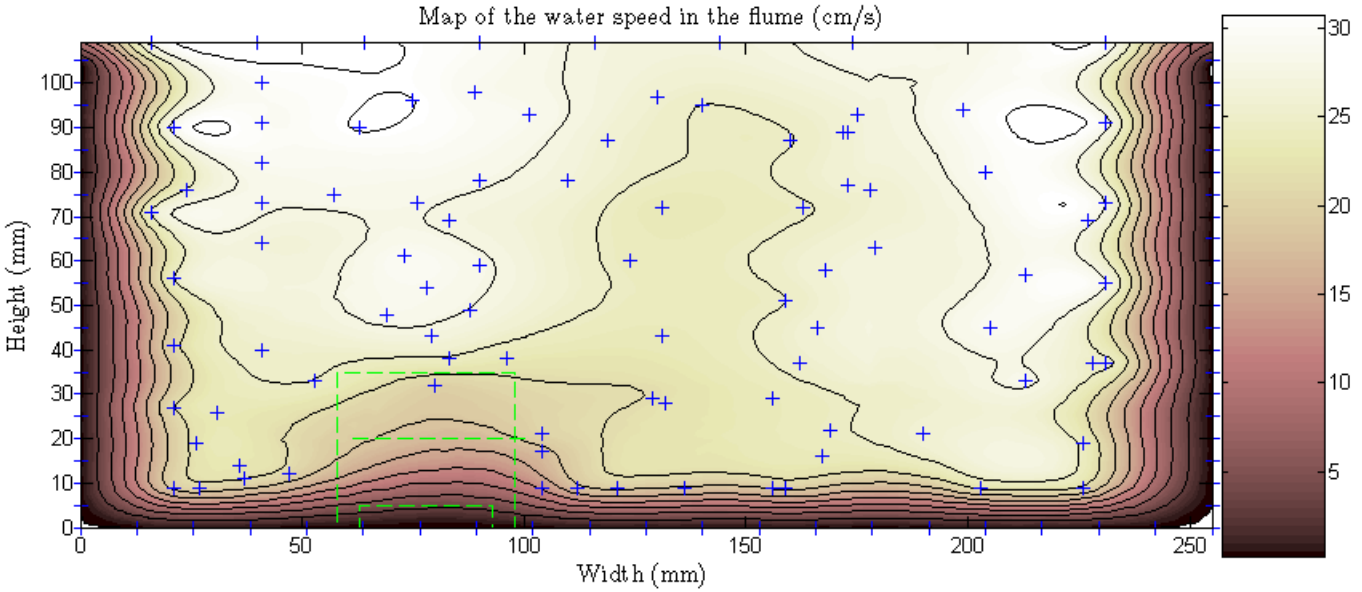
Validation of the choice of locations

Leave-one-out Diagnostics:

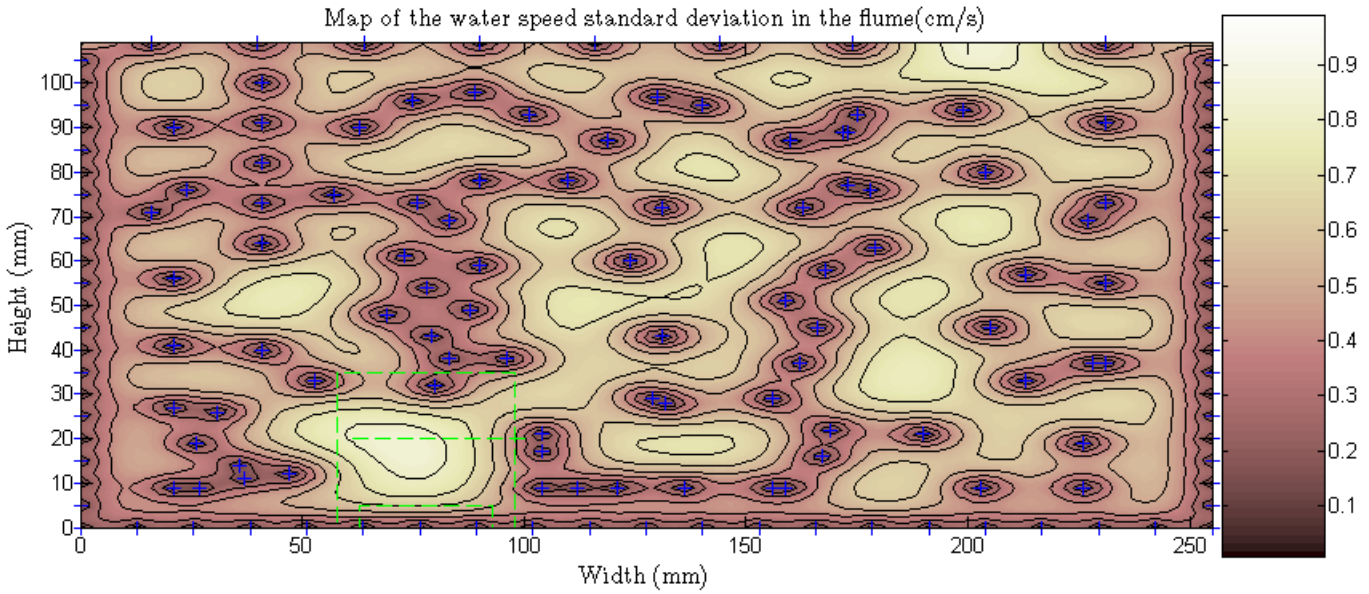
1. remove a speed flow meter location
2. predict speed flow there using all the other measures. Method used: kriging
3. compare the predictions with the original data



Comparison of leave-one-out predictions and observations over all sites (zeros correspond to boundary conditions)


Map of the water speed in the flume (cm/s)
Height (mm)
Width (mm)
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
5
10
15
20
25
30

Speed flows



Speed flows standard errors

Calibration of CFD computer model

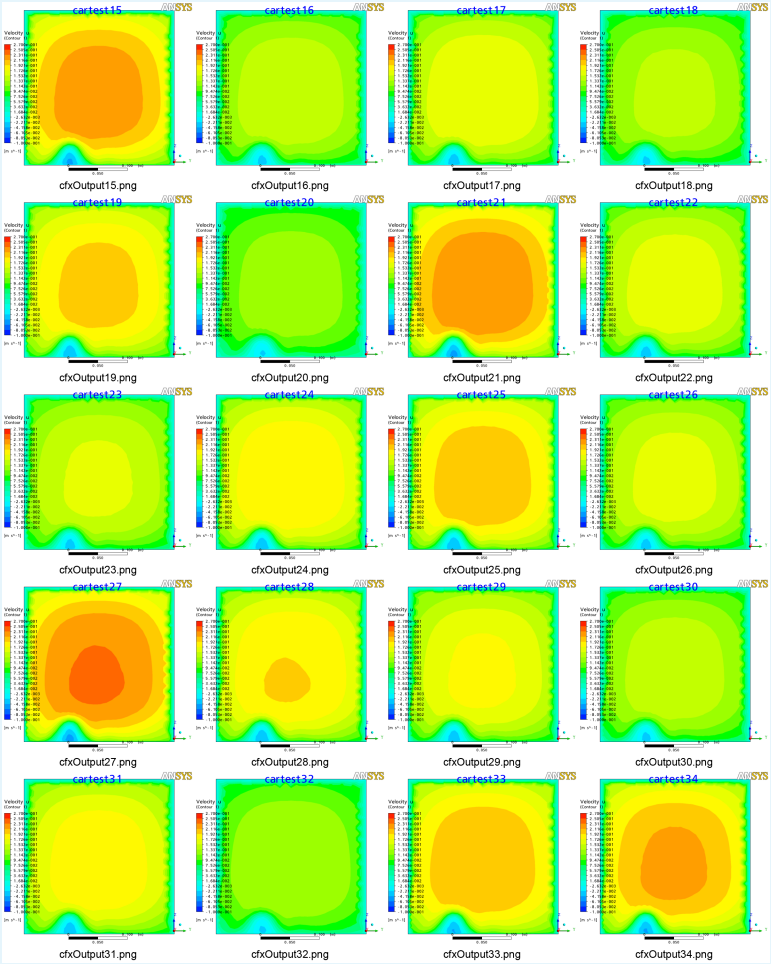
Parameters that give best model outputs?

Denote input parameters $z = (x, u)$. Two categories:

- **known parameters (controllable parameters x): geometry of the street cayon, size of car, temperature,..**
- **unknown parameters (calibration parameters u): inlet speed, eddy length scale and turbulence**

Data sampling and computer model representation:

1. Computer experiments are expensive and time consuming..so small subset of the parameters: design
2. In between, emulate the computer model by a Gaussian process response-surface
   (Sacks et al. 1989, Welch et al. 1992, Morris et al. 1993)



CFD runs under 20 combinations of the parameters

Representations of model bias and uncertainty:

Kennedy and O'Hagan (2001):
y^R : **reality**
y^M : **model output**
y^F : **field data**

Bias $b_u(x)$ and observation error ε:

$$y^R(x) = y^M(x,u) + b_u(x)$$
$$y^F(x) = y^R(x) + \varepsilon$$

Calibration procedure:

- fully Bayesian procedure:
  prior knowledge elicitation
- MCMC approach with Metropolis-Hastings
- draw realizations from the posterior distribution

Conclusion and future work

- accurate measurements, but only one slice, enhanced measurements necessary to understand the flow
- computational cost of CFD huge!
  Use of CFX on parralel cluster: Legion at UCL
- sequential design? (Gramacy and Lee, '09)
- improved choice of parameters for the numerical model