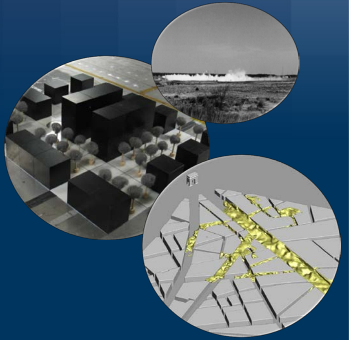
MODITIC

Modelling the dispersion of toxic industrial chemicals in urban environments

On the generation of inflow boundary conditions for dispersion simulations using Large Eddy Simulations.



Harmo'17

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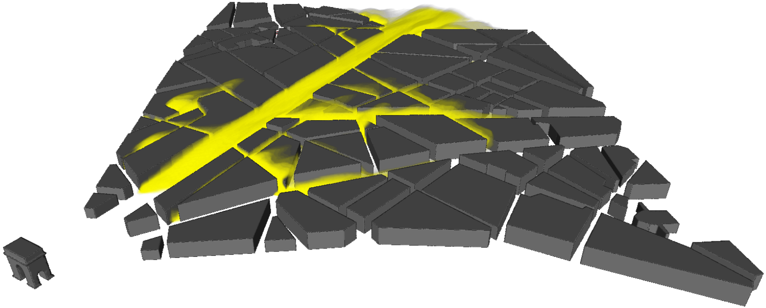
Motivation: Correct inflow conditions are crucial to successful use of Large Eddy Simulations in dispersion simulations!



Overview

Three methods for generating inflow conditions

I Proper orthogonal decomposition with Linear Stochastic Estimation

II Synthethic turbulence

III Roughness elements precursor simulation

Two sets of experimental data

WALLTURB [1]
Laboratoire de Méchanique de Lille
Flat-plate boundary layer
Cross section: 1×2 m
$U_\infty \approx 10$ m/s
$\mathrm{Re}_\theta \approx 20000$

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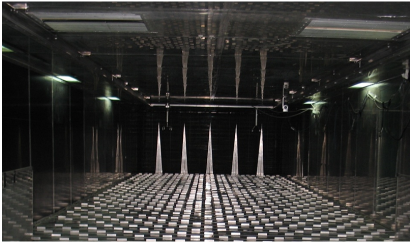
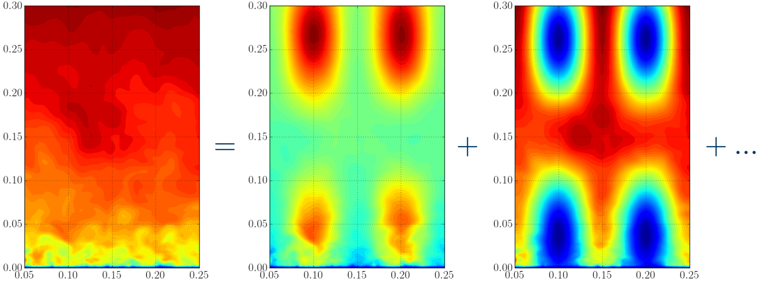
Roughness boundary layer
Cross section: 3×1.5 m
$U_\infty \approx 1$ m/s
$\mathrm{Re}_\theta \approx 6000$



Proper orthogonal decomposition is used to decompose the velocity field into a set of modes

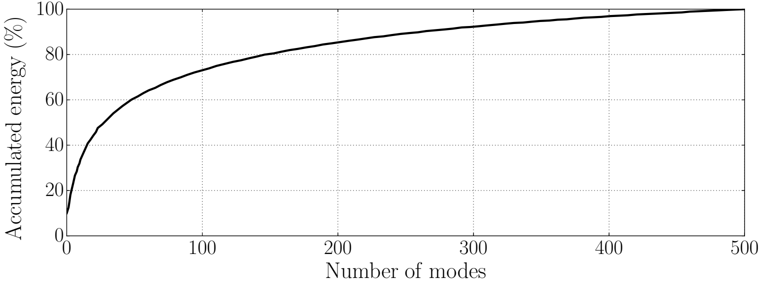


Modes are found by:

$$\int_D R_{ij}\left(y, y', z, z'\right) \phi_j^{(n)}\left(y', z'\right) dy' dz' = \lambda^{(n)} \phi_i^{(n)}\left(y, z\right)$$

$$R_{ij}\left(y, y', z, z'\right) = \langle u_i(y,z) u_j(y',z') \rangle$$

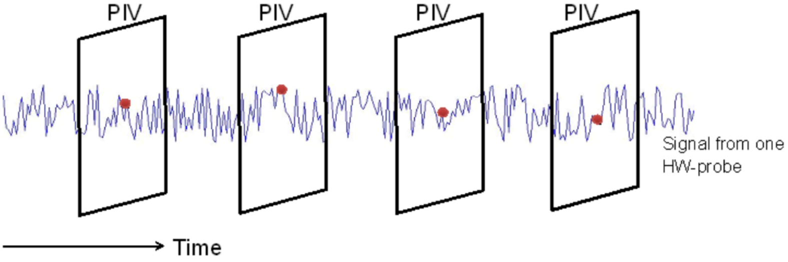
Reconstruction of velocity field can be done using a truncated set of modes



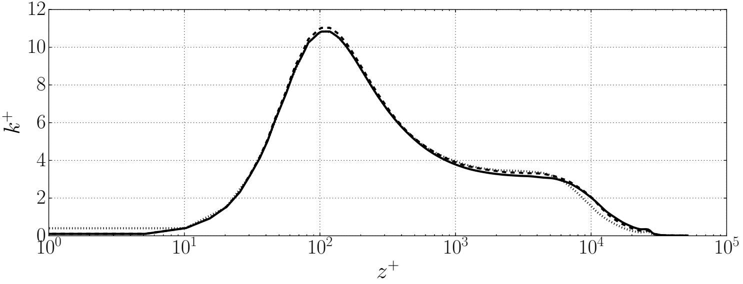
Decomposition: $$a^{(n)} = \int_D u_i\,(y,z)\,\phi_i^{(n)} dydz$$

Reconstruction: $$u_i^{(n)}(y,z) = \sum_{i=1}^{N} a^{(n)} \phi_i^{(n)}(y,z)$$

High spatial and temporal resolution achieved using Linear Stochastic Estimation on PIV and Hotwire data



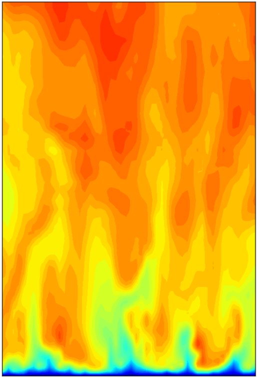
POD-LSE simulation results



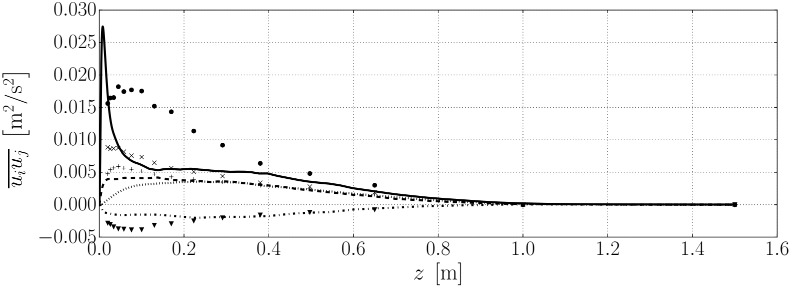
——— : 100% energy
- - - - : 75% energy
············ : 50% energy

Incompressible finite volume solver [2].

Synthethic turbulence



Synthetic turbulence results



Lines: Numerical results. Symbols: Experimental results.

——— and •: $\overline{uu}$, - - - - and ×: $\overline{vv}$,

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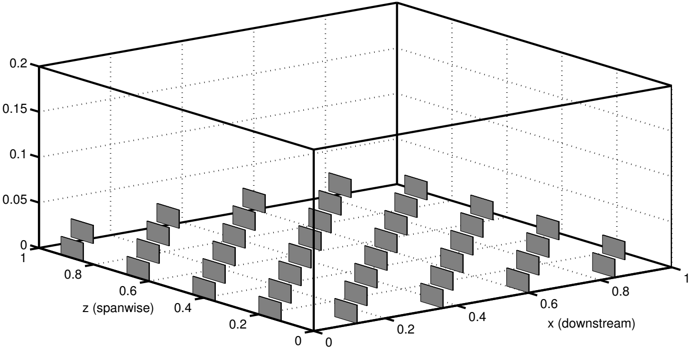
Roughness elements precursor simulation



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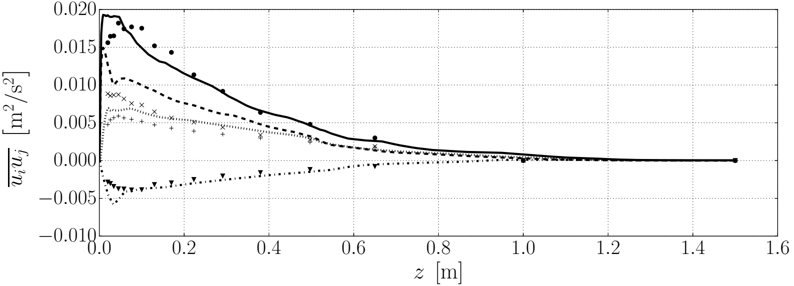
Turbulence statistics agree very well with experimental data using the roughness elements precursor simulation!



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Conclusions

- The POD-LSE method works well for reproducing the flow on which it was based. It is not however easily applicable to arbitrary flows.
- The synthetic turbulence method did not give satisfactory results for these simulations.
- Simulating the complete wind-tunnel geometry, (in this case by including roughness elements) accurately reproduces the flow but is computationally expensive and work-intensive.

References

[1] Delville et al. 2011, The WALLTURB Joined Experiment to Assess the Large Scale Structures in a High Reynolds Number Turbulent Boundary Layer, Progress in Wall Turbulence: Understanding and Modeling.

[2] Cascade Technologies Inc. 2014, Users & Developers Manual, Jefferson Release Version 4.1.0