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Evaluation of the Traffic Producing Turbulence within a modelled street canyon using Computational Fluid Dynamics

Efisio Solazzo[1], Xiaoming Cai[1], Sotiris Vardoulakis[2]

[1]University of Birmingham

[2]London School of Hygiene and Tropical Medicine

Scope…

Evaluating the production of flow and turbulence induced by the wind and moving vehicle within urban street canyons-type geometry

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- Producing useful operational parameterisations to be included into operational dispersion models for streets.
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How…

By means of numerical models:
- Operational models + roadside measurements (Poster, p. 317);
- Computational Fluid Dynamics (CFD) calculations (Validation is needed)

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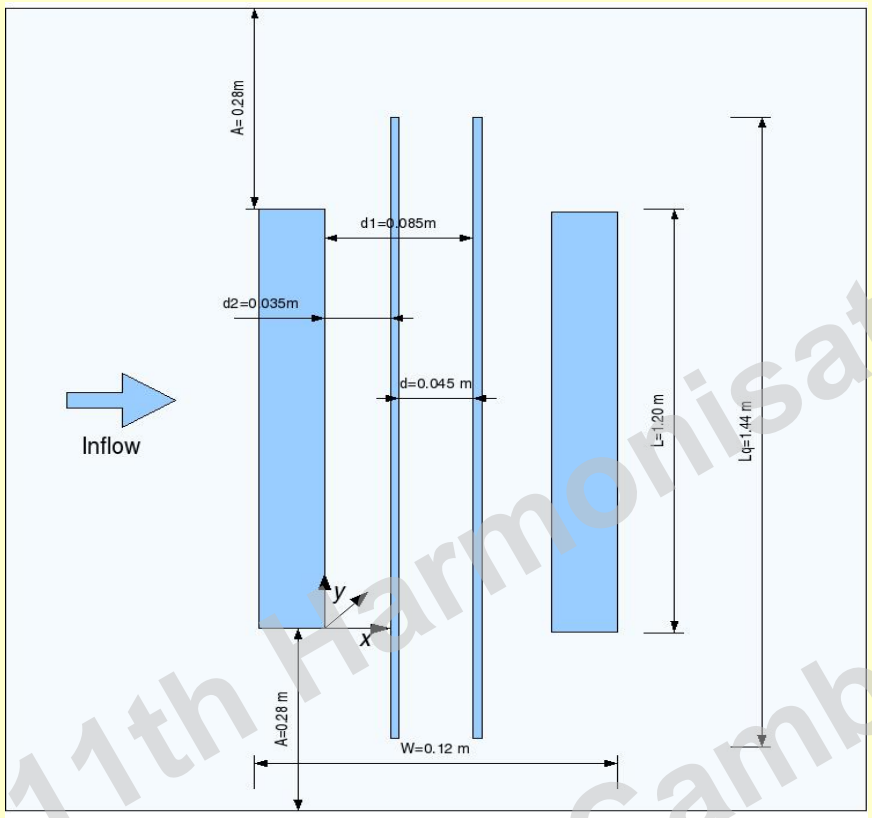
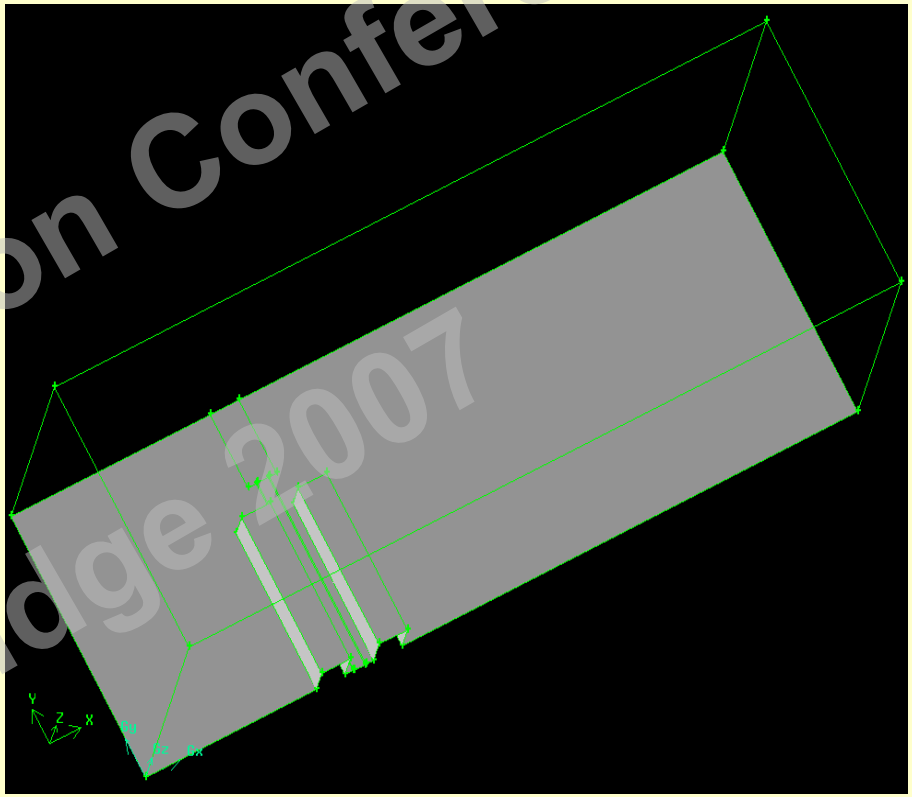
1) Evaluation using published wind tunnel data (P. K.-Klein)





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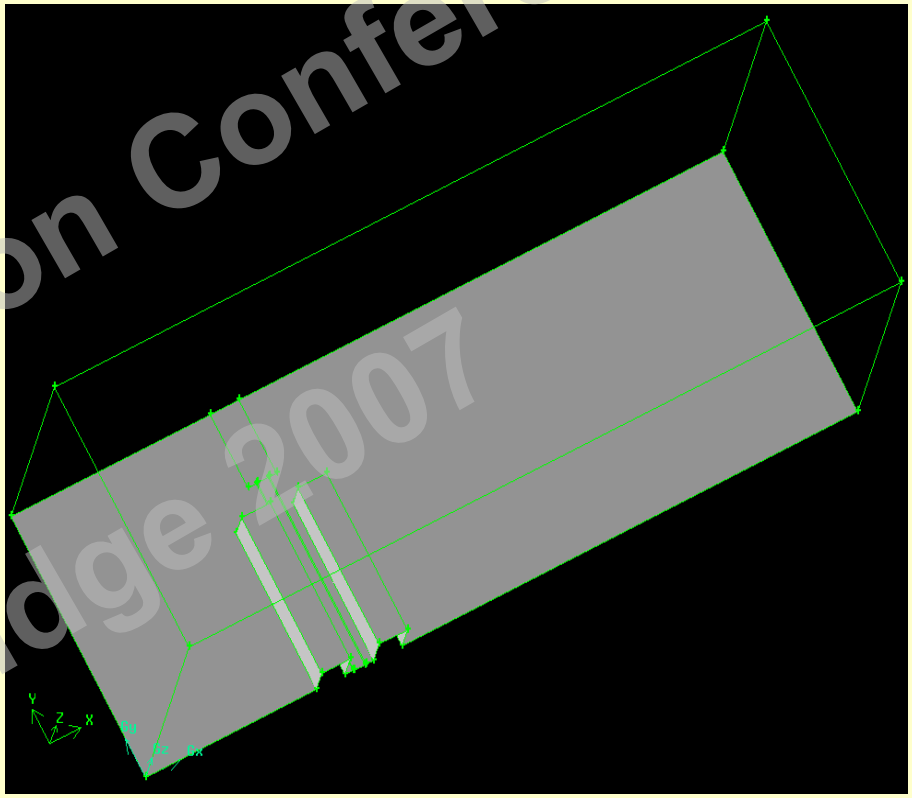
1) Evaluation using wind tunnel data

Standard k-ε model

$$U(z) = \frac{u_*}{\kappa} \ln\left(\frac{z + z_0}{z_0}\right)$$

$$k = \frac{u_*^2}{\sqrt{C_\mu}}\left(1 - \frac{z}{\delta}\right)$$

$$\varepsilon = \frac{u_*^3}{\kappa(z + z_0)}\left(1 - \frac{z}{\delta}\right)$$



	σ_k	σ_ε	δ (m)	U_δ (m s^{-1})	u_* (m s^{-1})	z_0 (m)
modified	0.53	0.55 for z < 1.25 H; 1.30 elsewhere	0.480	7.0	0.429	0.0007
(default)	(1.00)	(1.30)				

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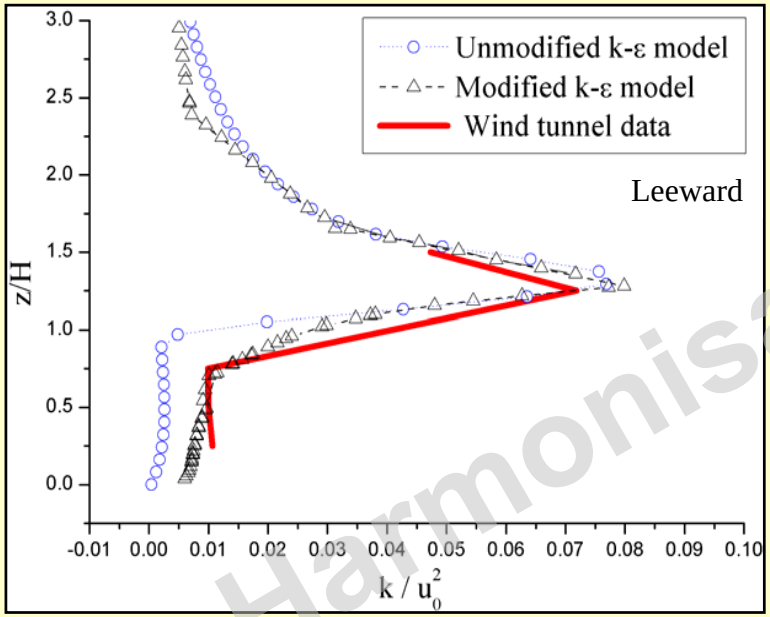

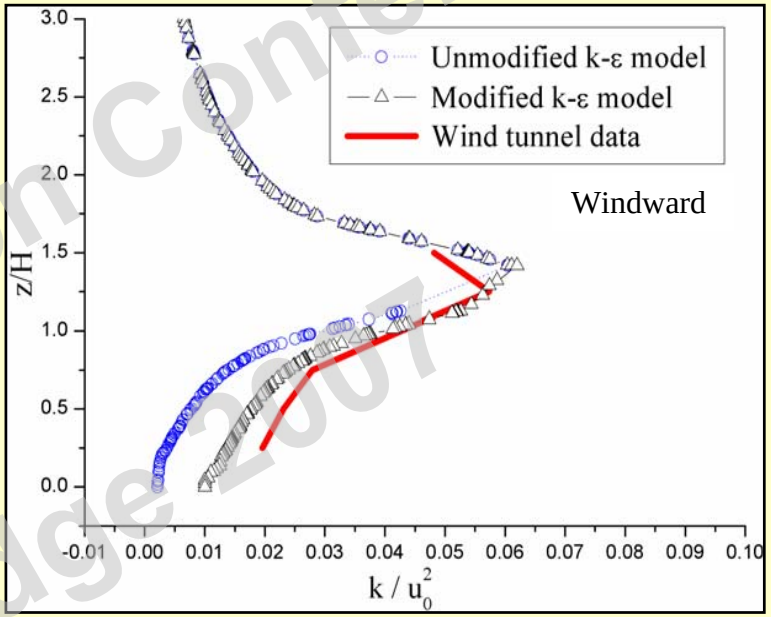

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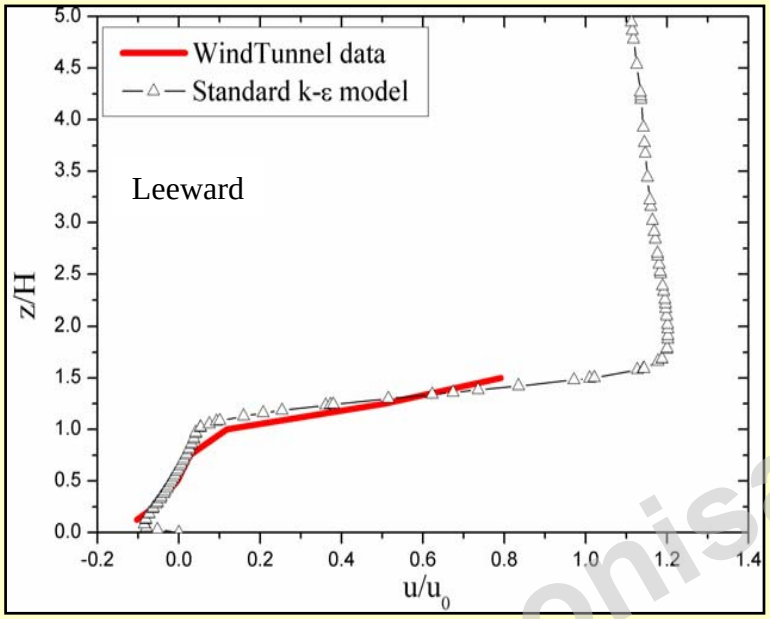

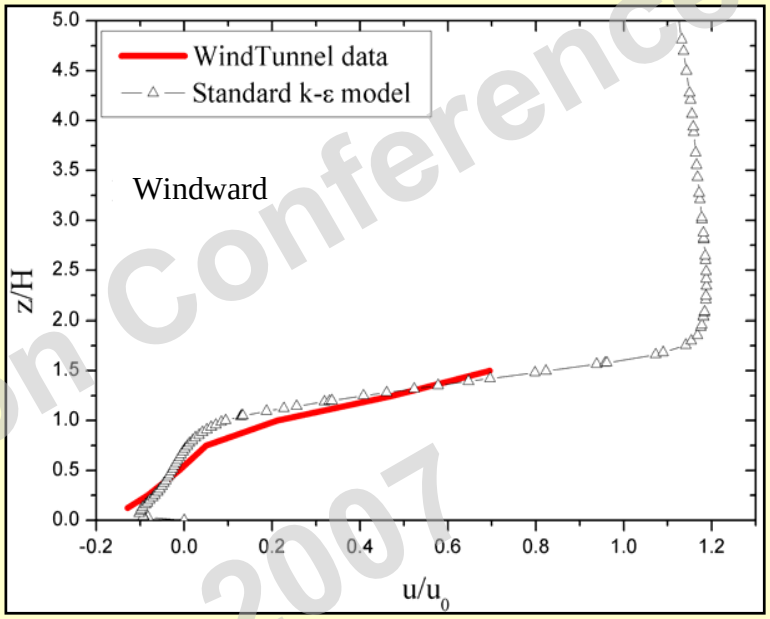

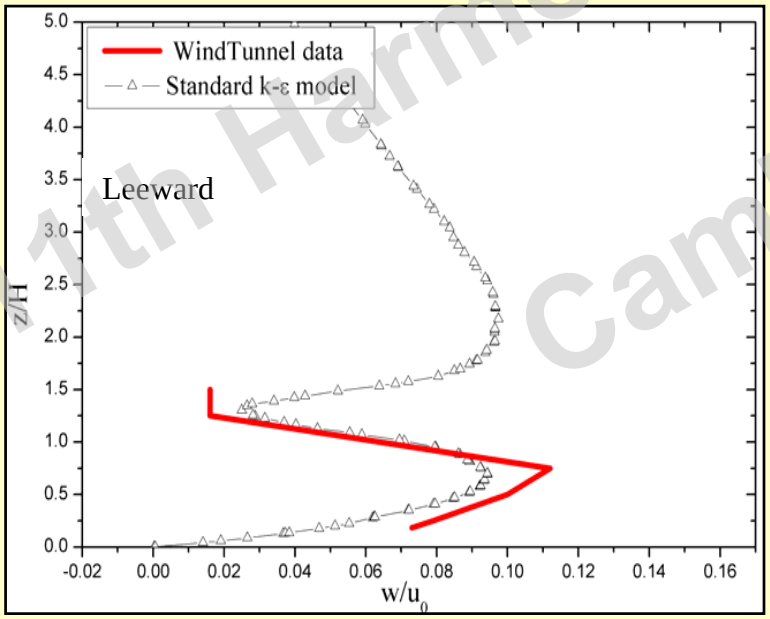

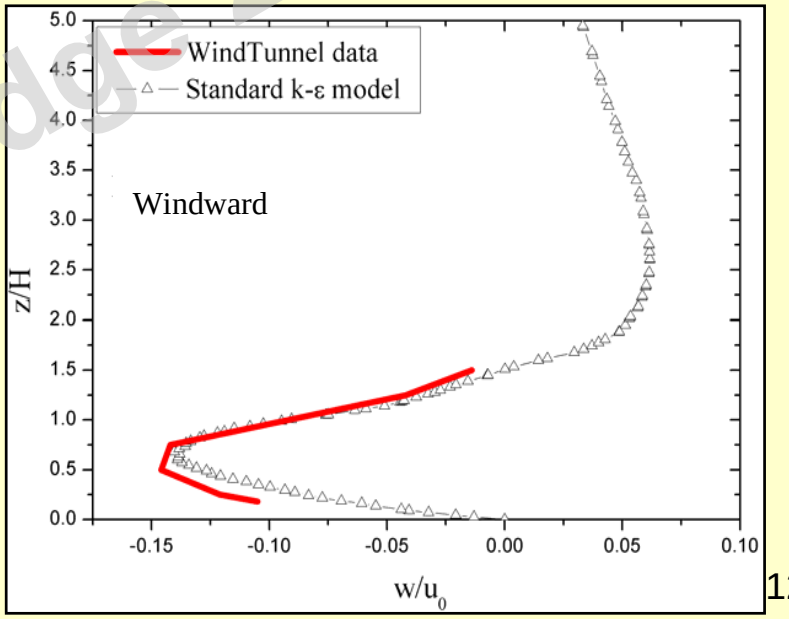

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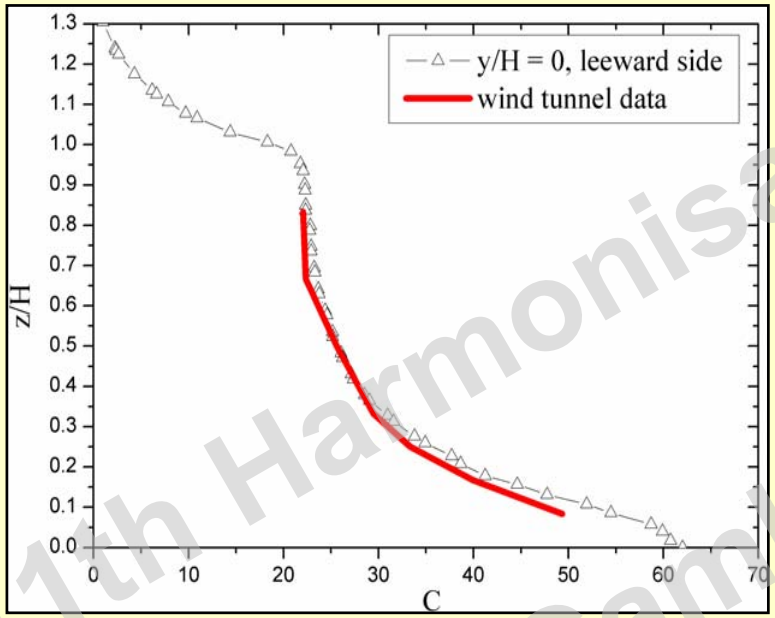

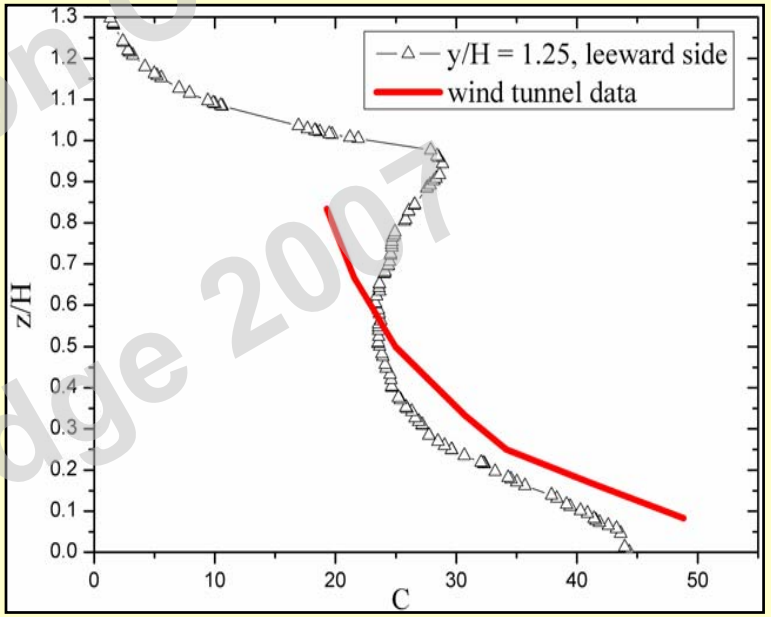

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At any given point within the street canyon turbulence is due to:

I. Turbulence in the atmosphere;

II. deformation of the flow due to the passing vehicle

III. turbulence in the wake

the organised flow is due to:

IV. external wind flow;

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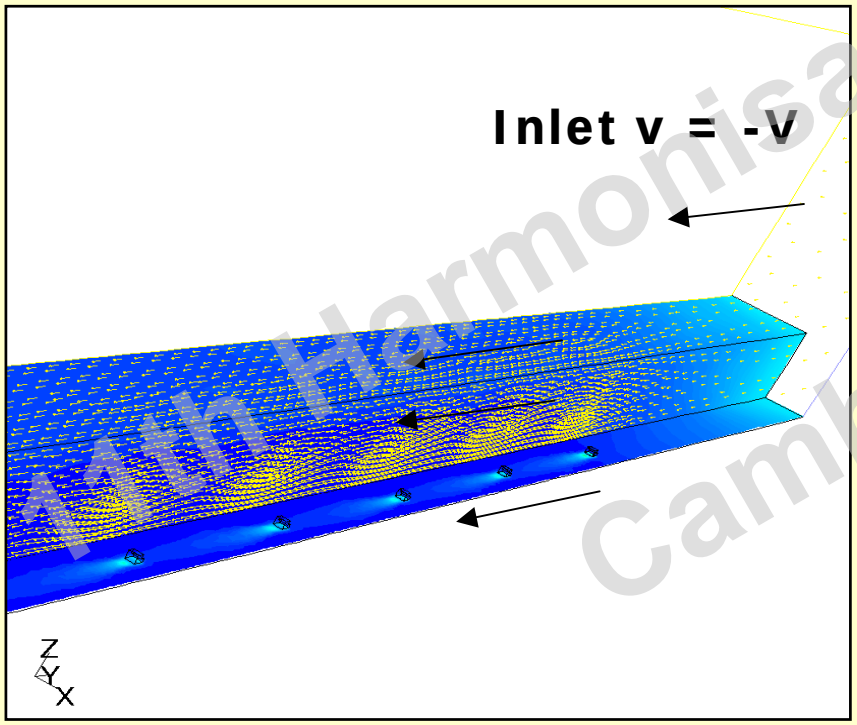

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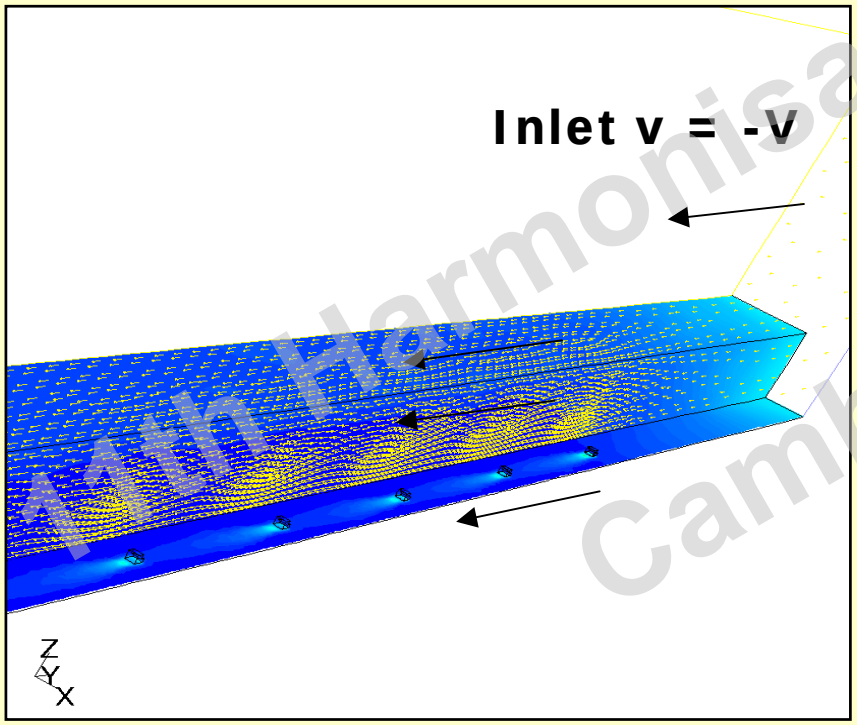

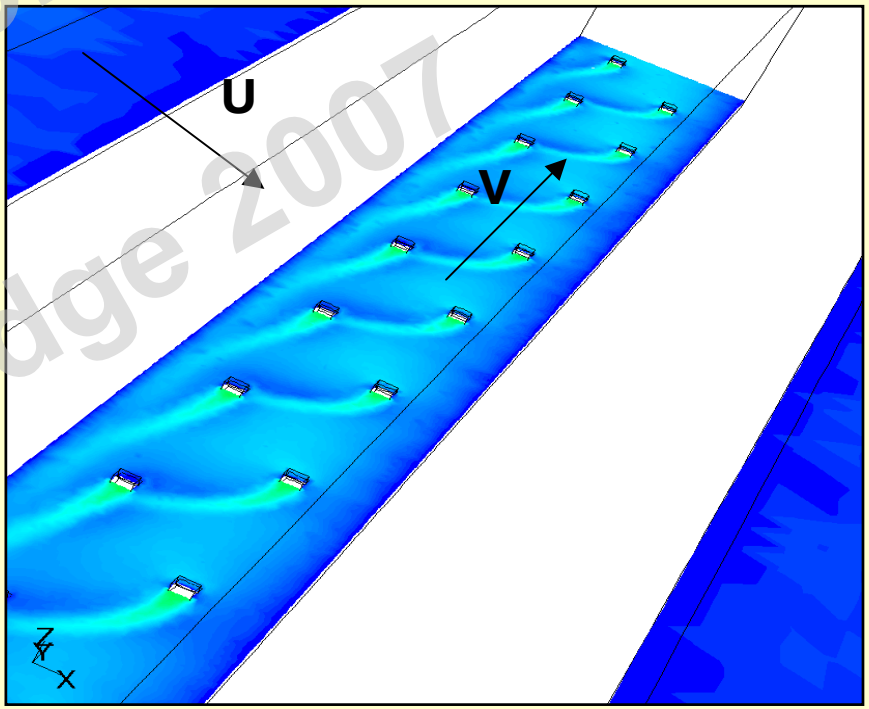

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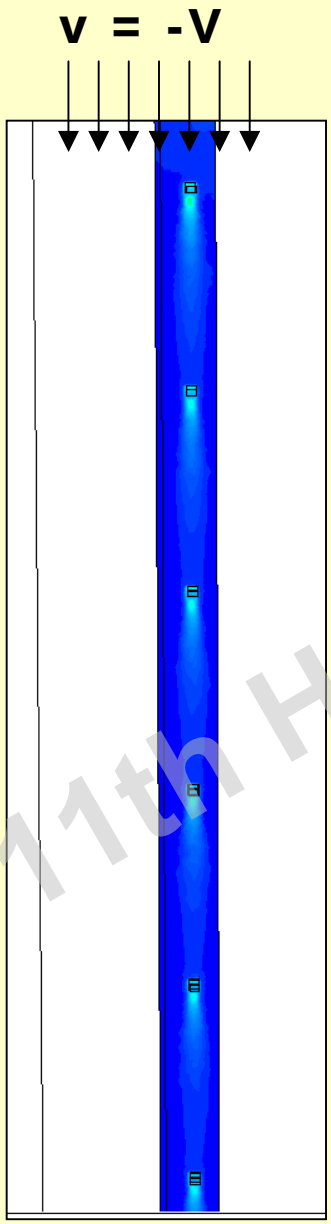

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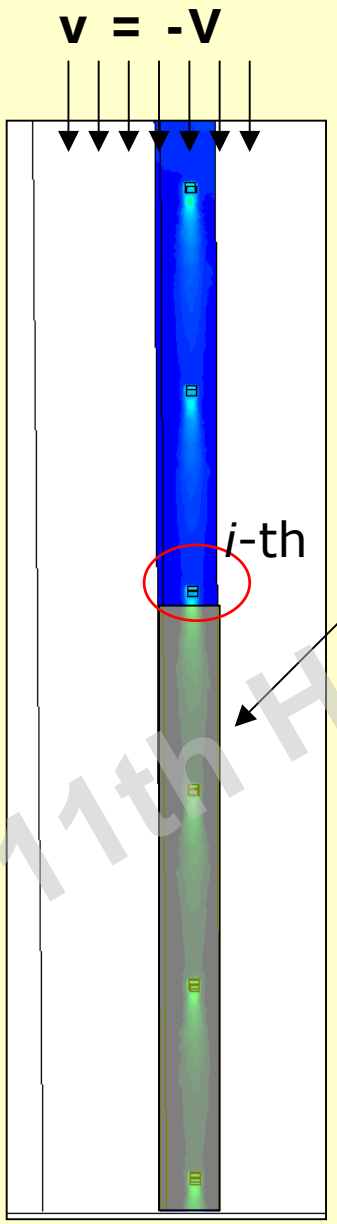

Fluid-zone down-stream *i*-th vehicle

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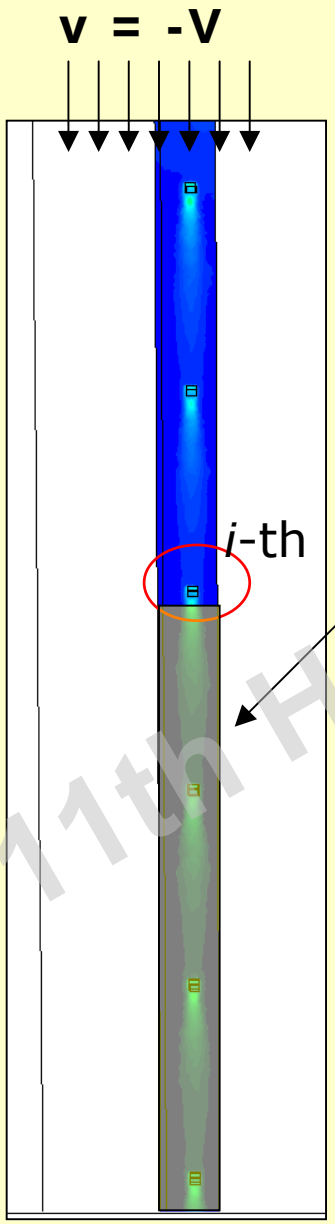

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$$\left\{\begin{matrix}\vec{T}(u,v,w)\\ k(x,y,z)\end{matrix}\right\}_i = \left\{\begin{matrix}u(x,y,z)\\ v(x,y,z)\\ w(x,y,z)\\ k(x,y,z)\end{matrix}\right\}_i$$

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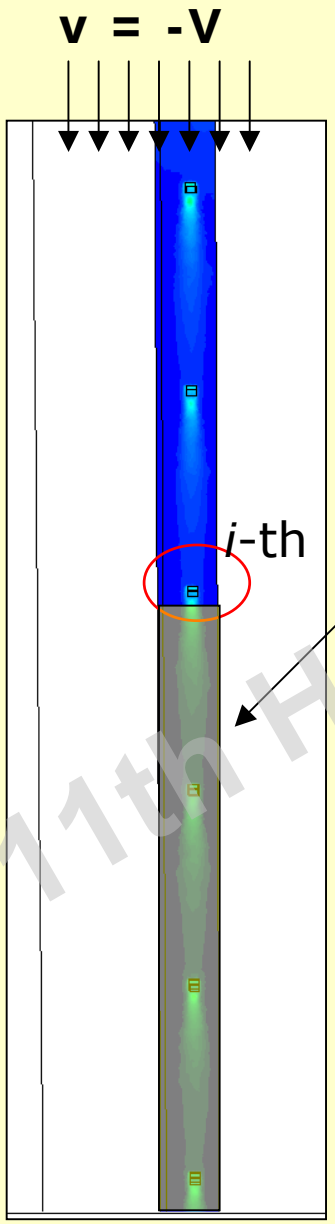

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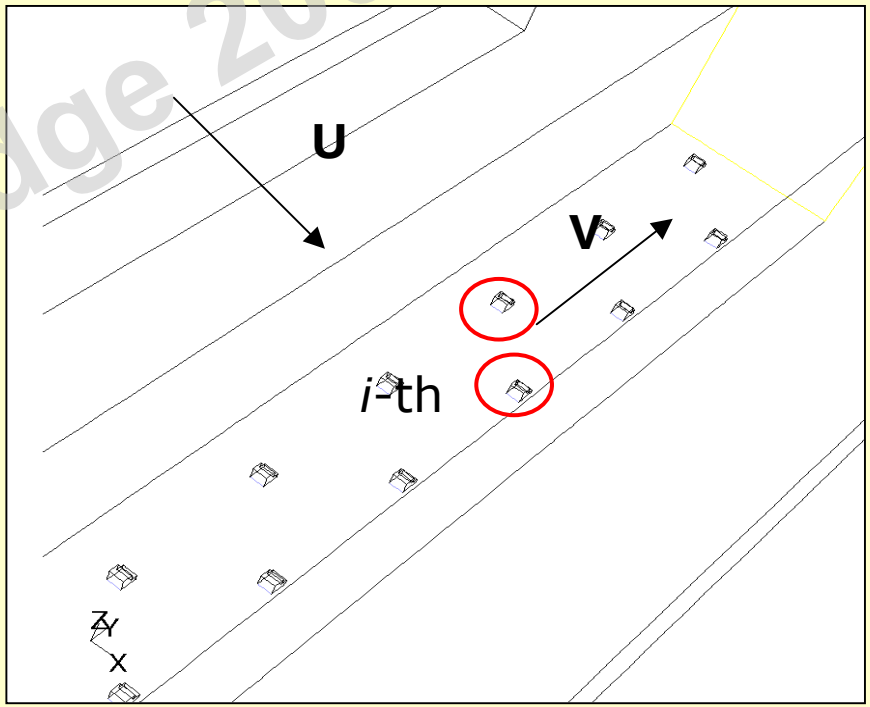

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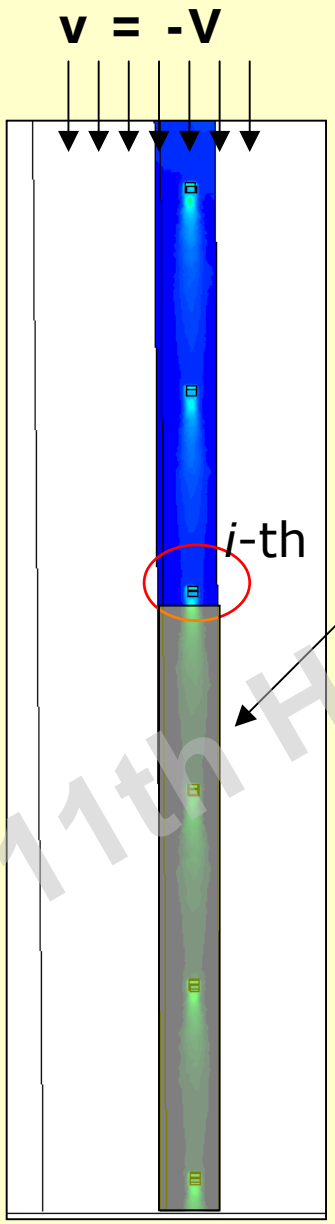

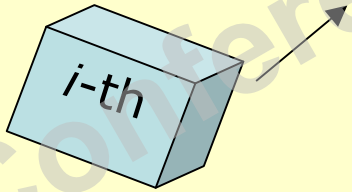

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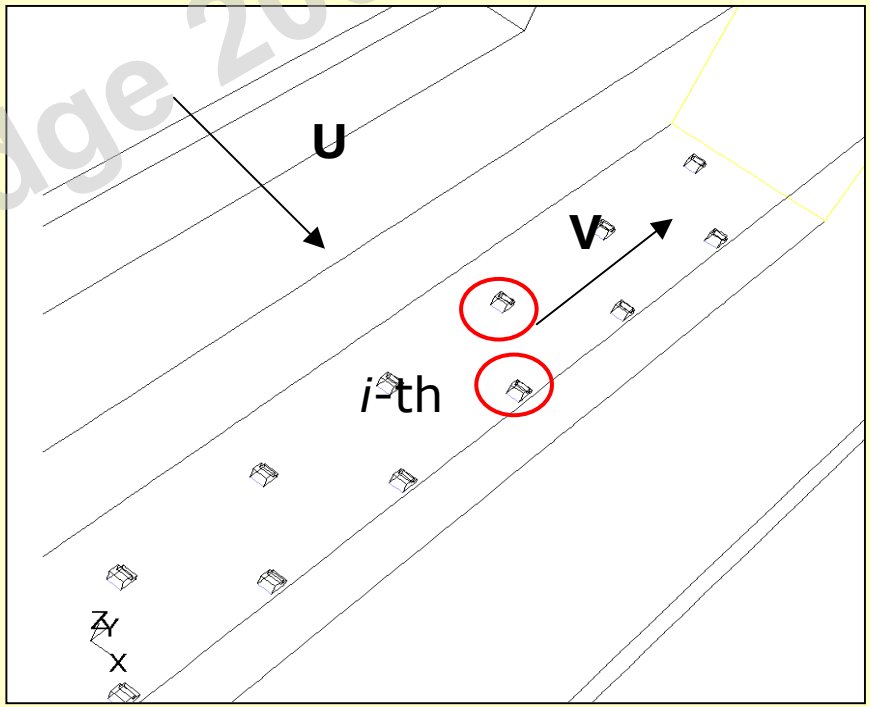

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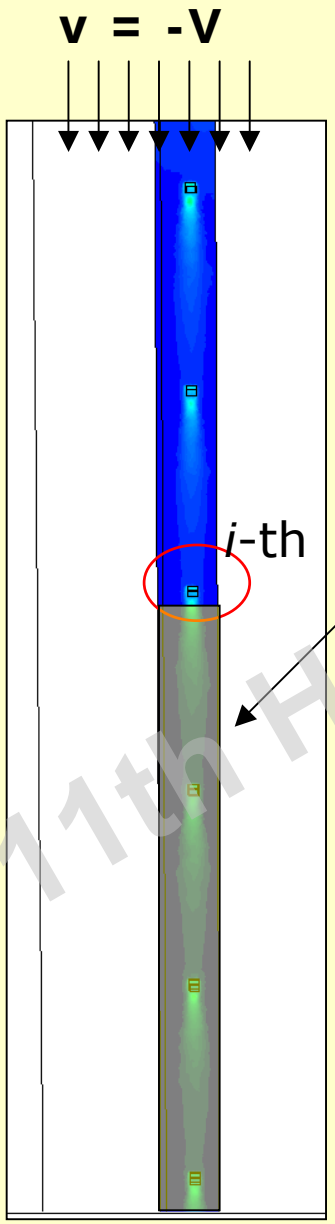

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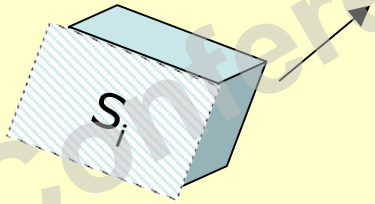
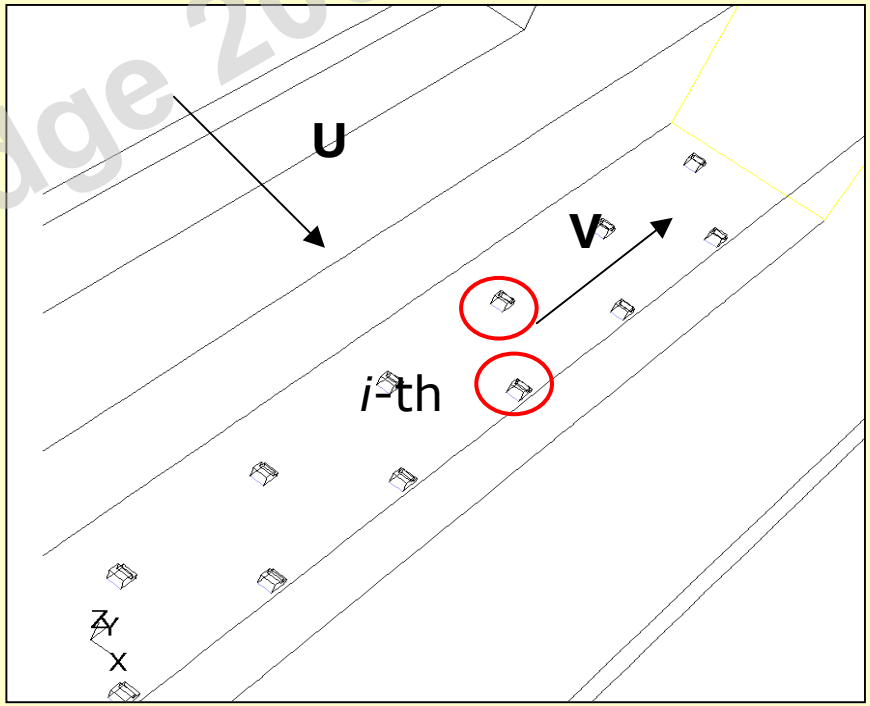


$$\begin{Bmatrix} \vec{T} \\ k \end{Bmatrix}_i$$

Inlet boundary condition at S_i



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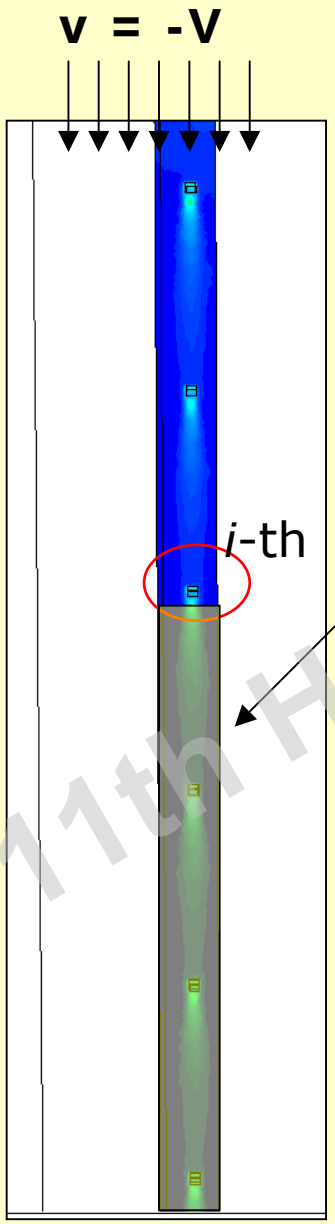

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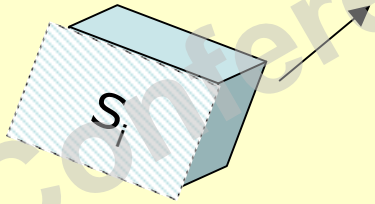

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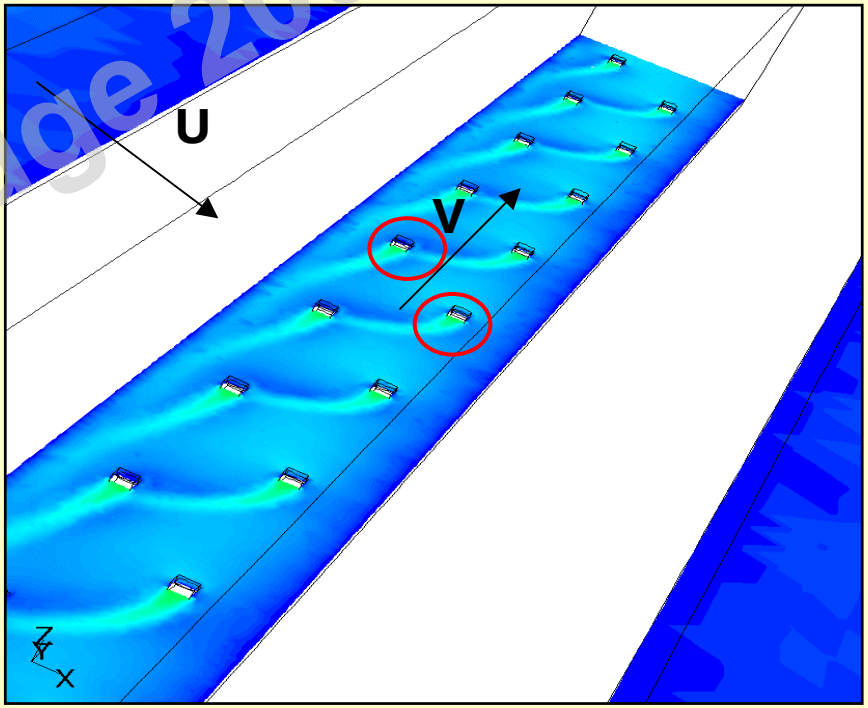

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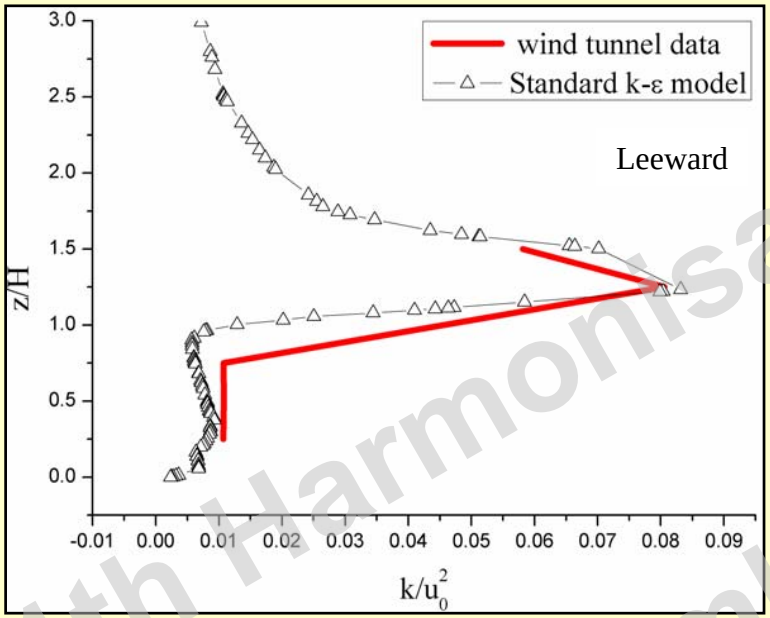

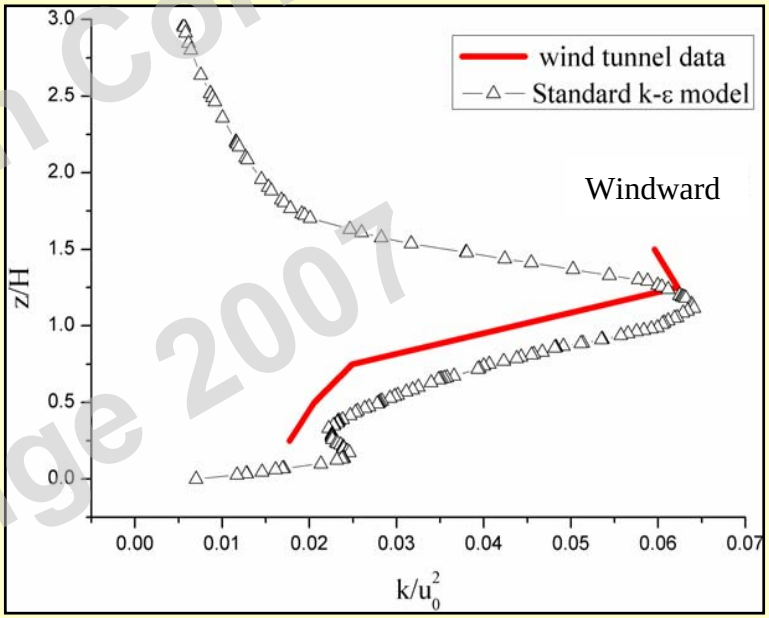

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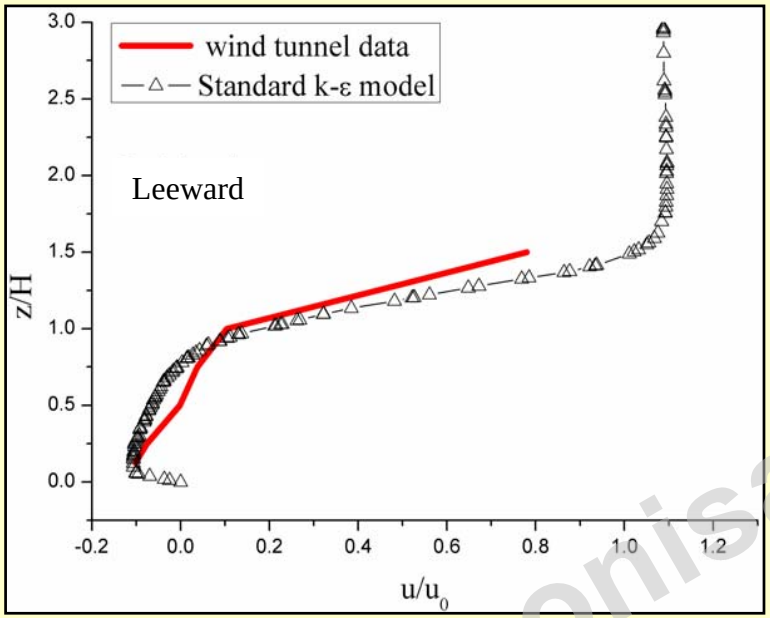

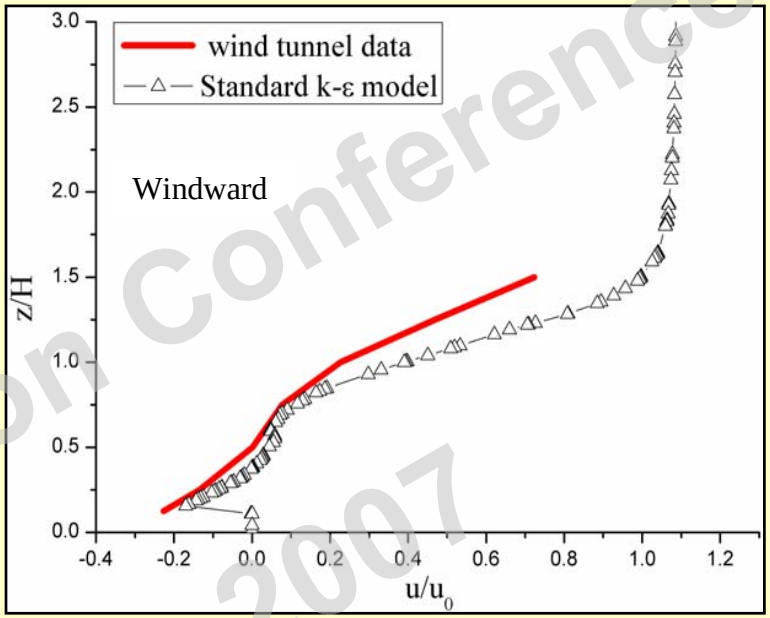

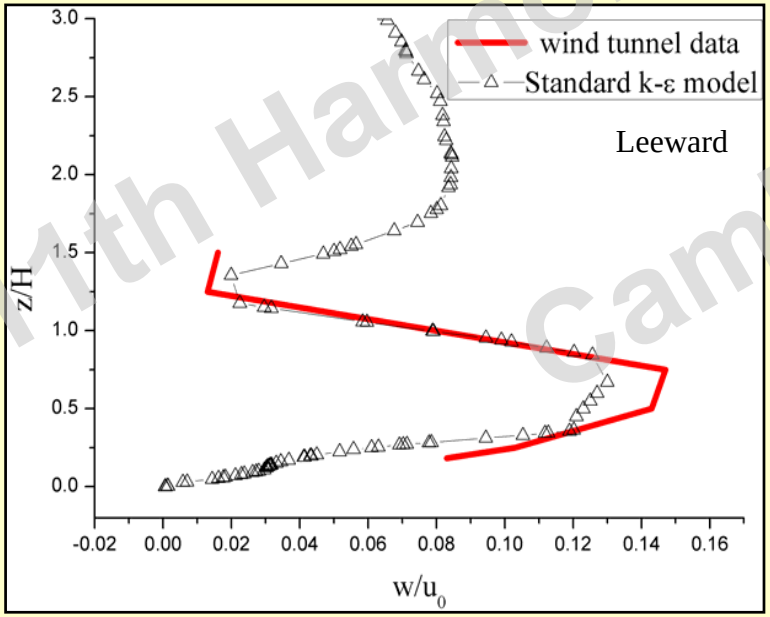

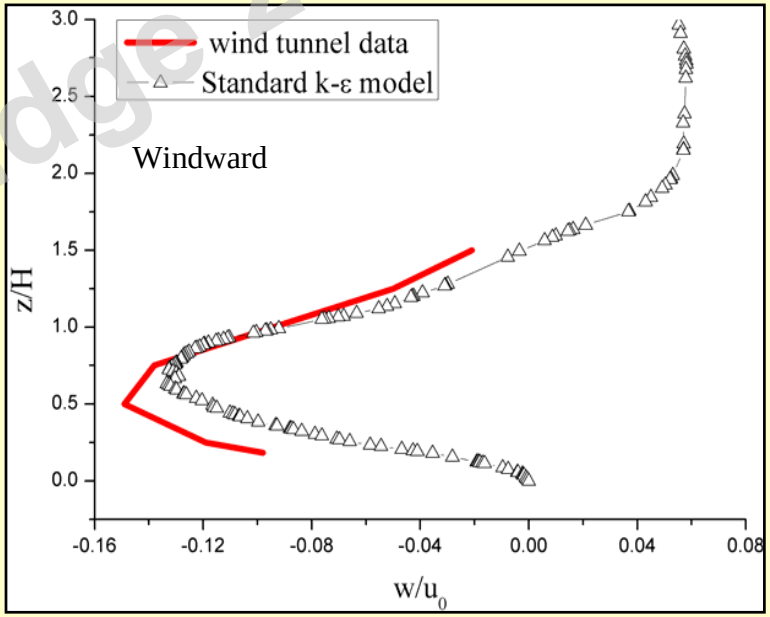

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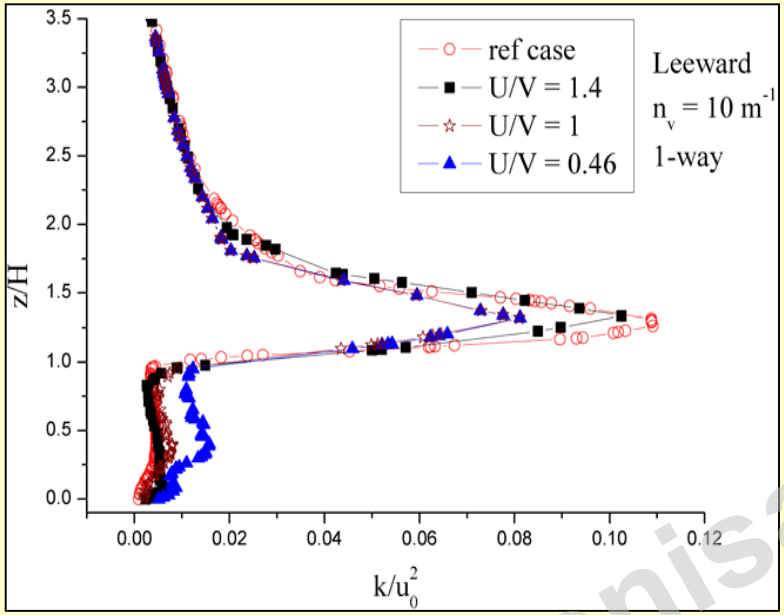

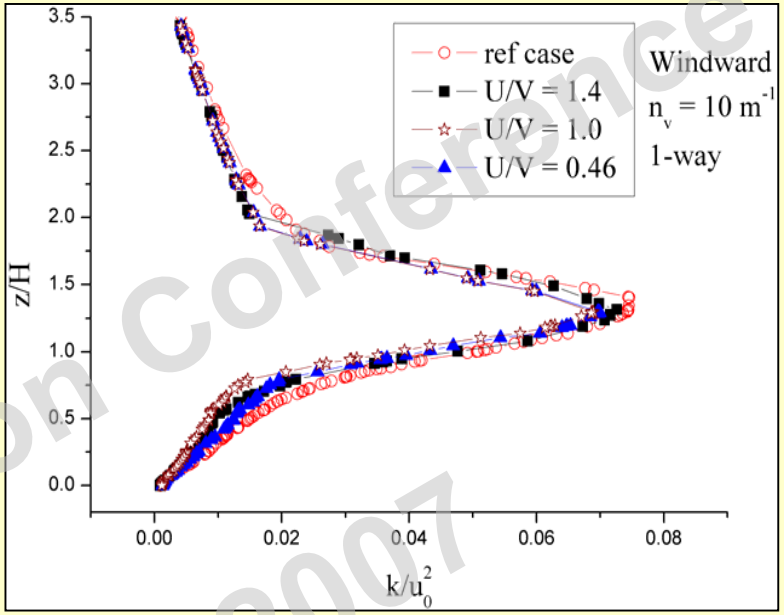

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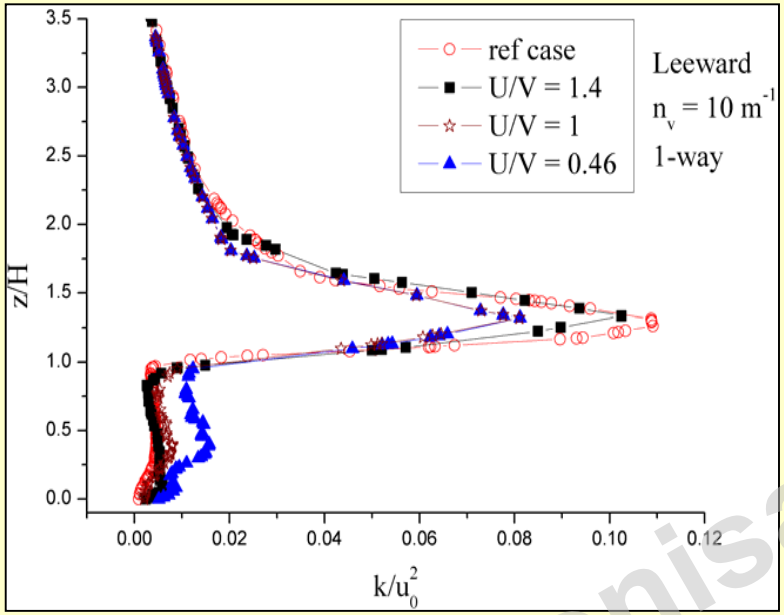

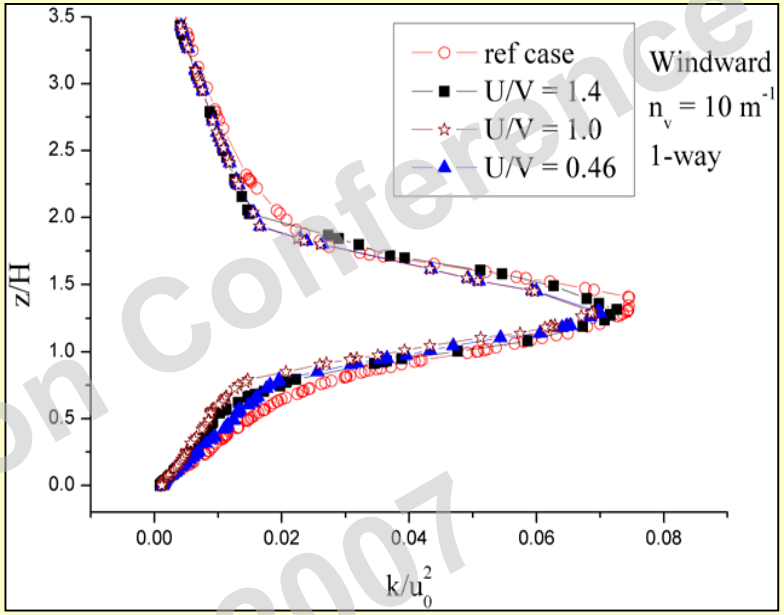

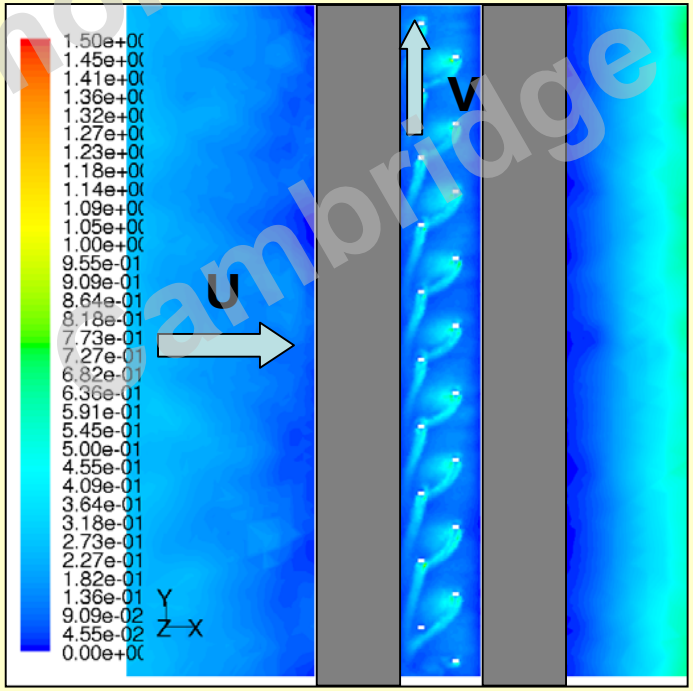

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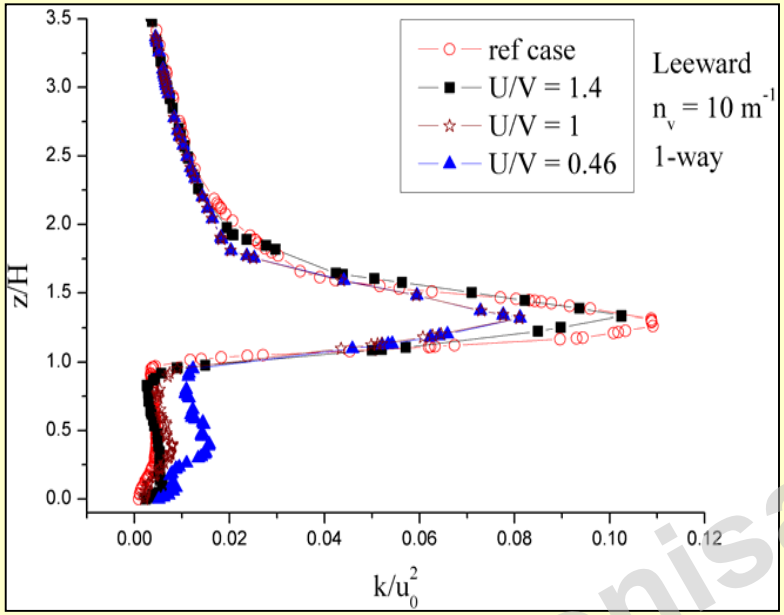

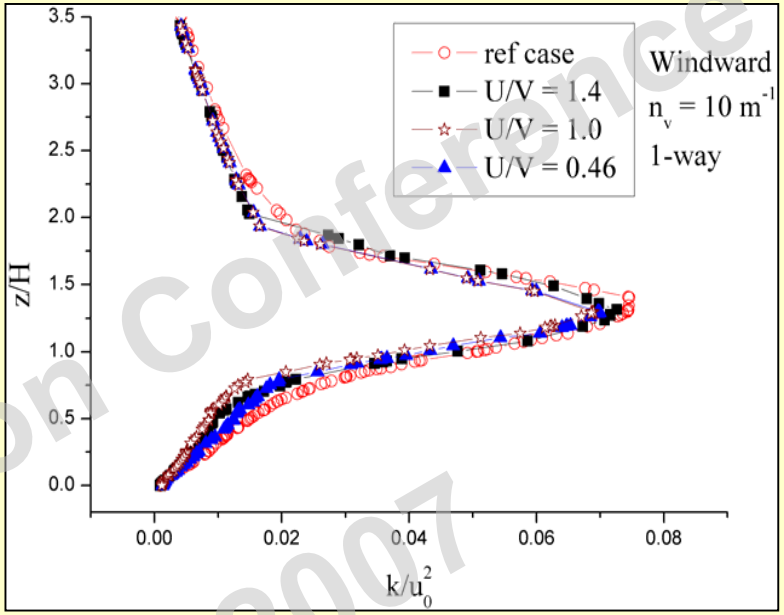

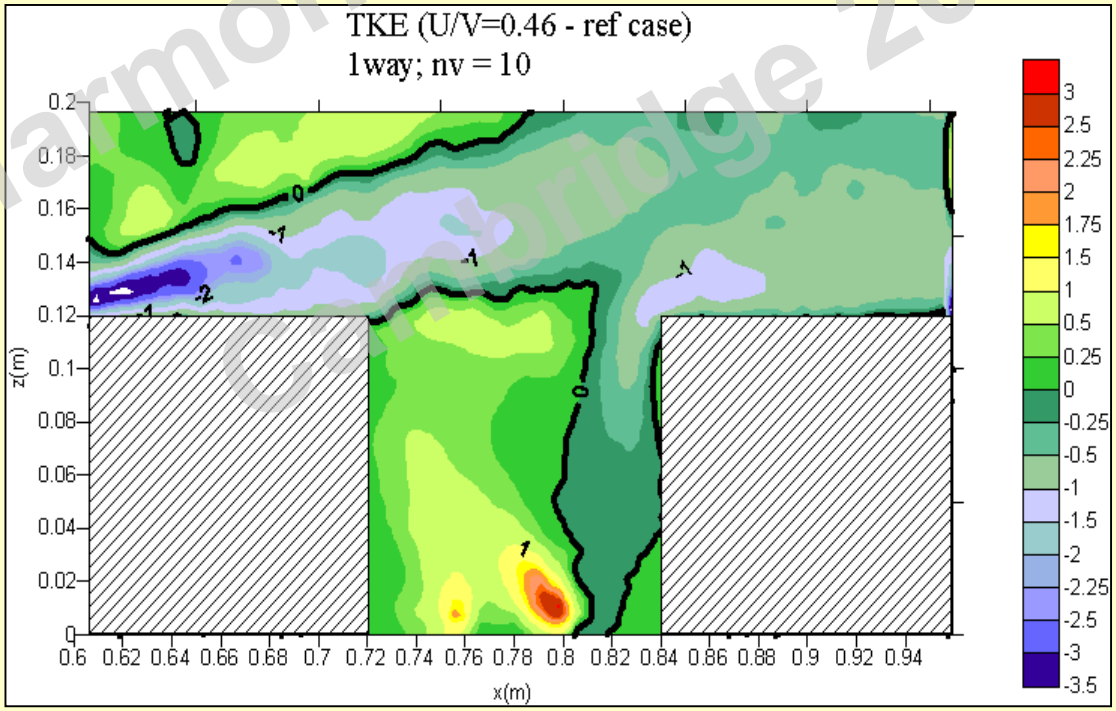

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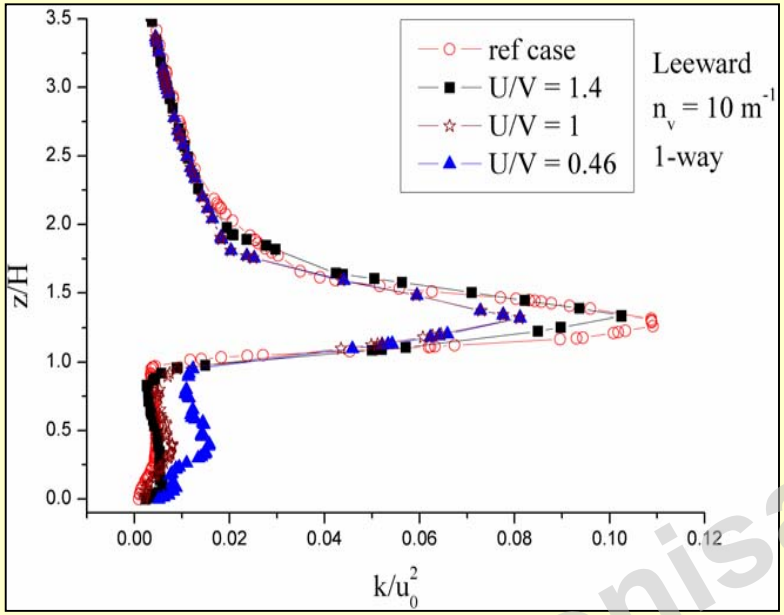

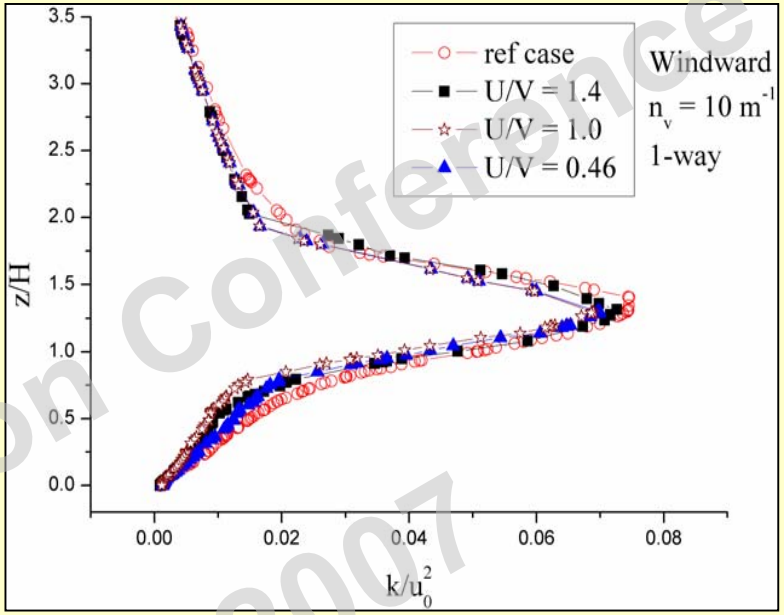

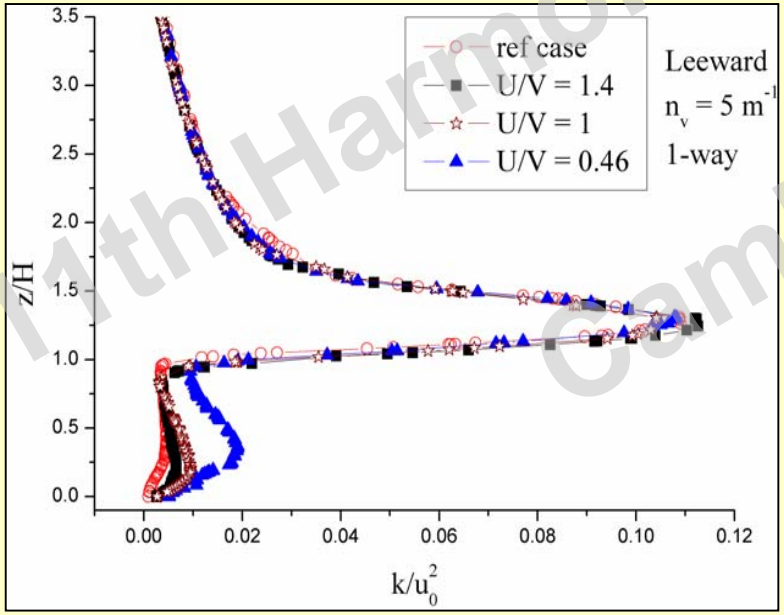

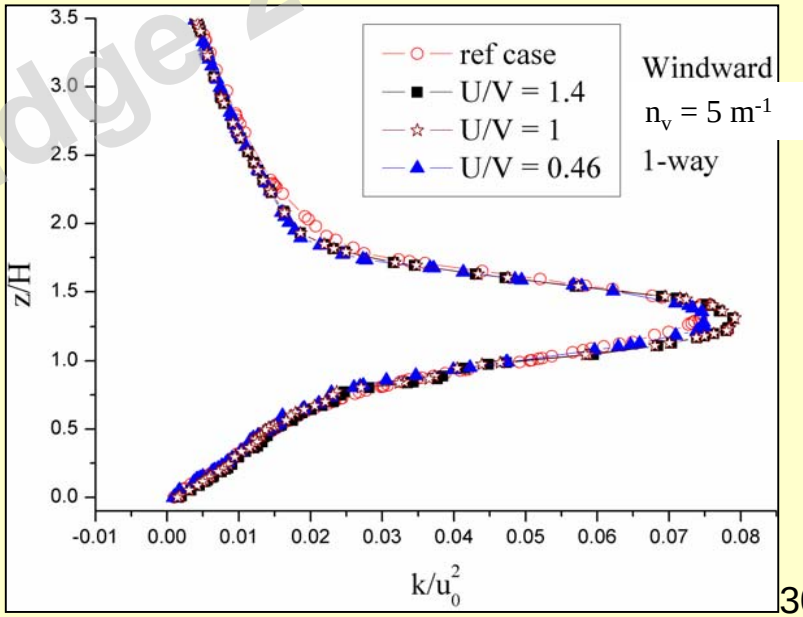

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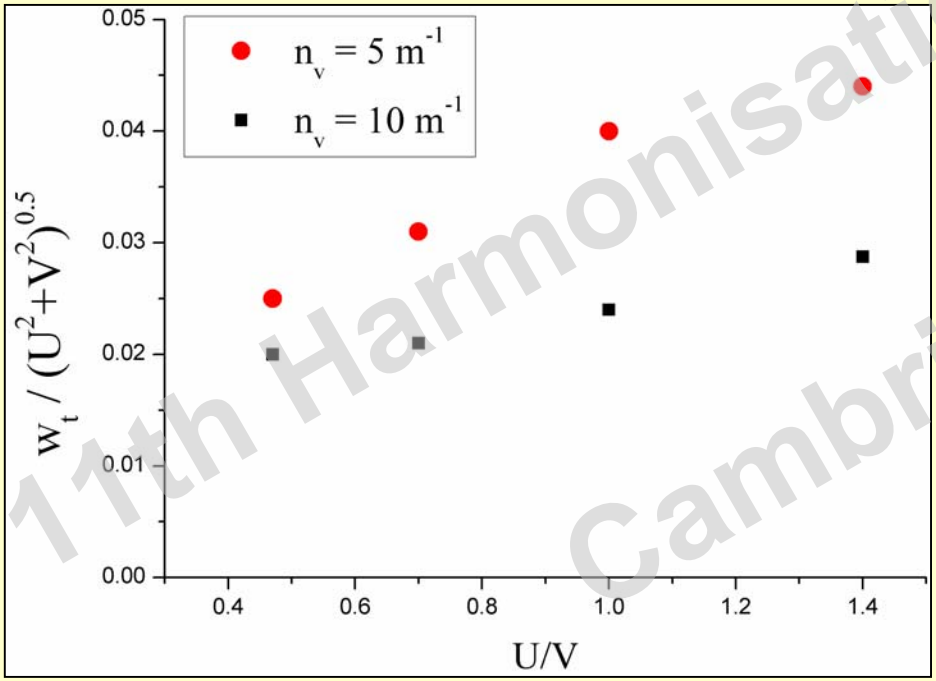
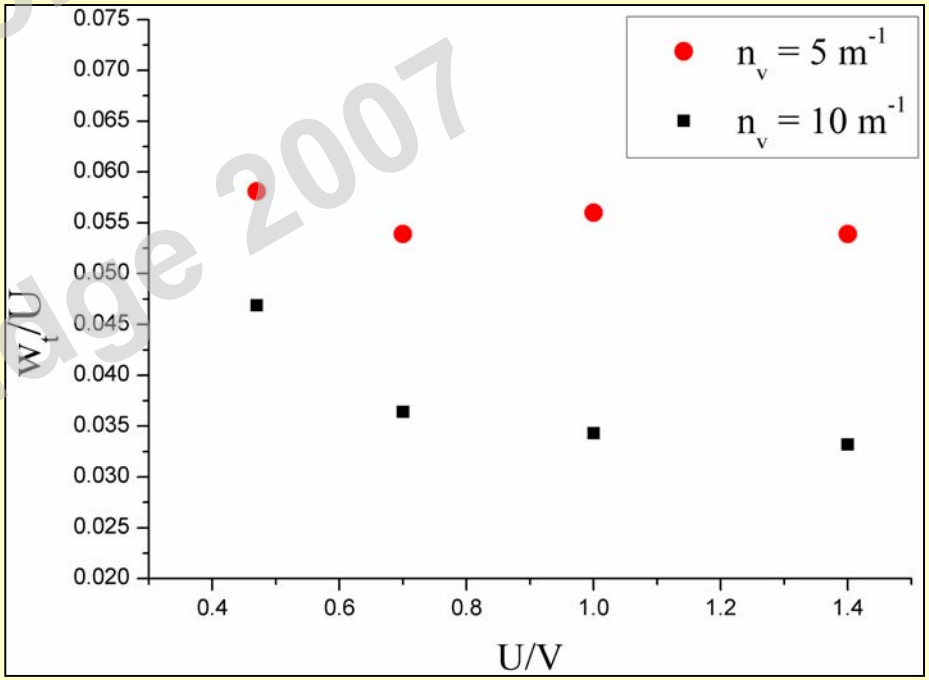
3) Some result so far…

$$mass\ \ flux\ \ density = w_t\ \Delta Conc$$

w_t = transfer velocity across the canyon top





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Conclusions and further develpments

- CFD model was evaluated with wind tunnel data for the case with wind flow only;

- A methodology to incorporate the vehicle motion at street level was introduced;

-The methodology was evaluated with wind tunnel data for the case with moving vehicle + wind flow;

-Early results prove the potentiality of such approach in deriving useful parameterisation to be included within an operational context.

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Thanks to

Xiaoming Cai and Sotiris Vardoulakis

Petra Kastner-Klein for providing the wind tunnel data

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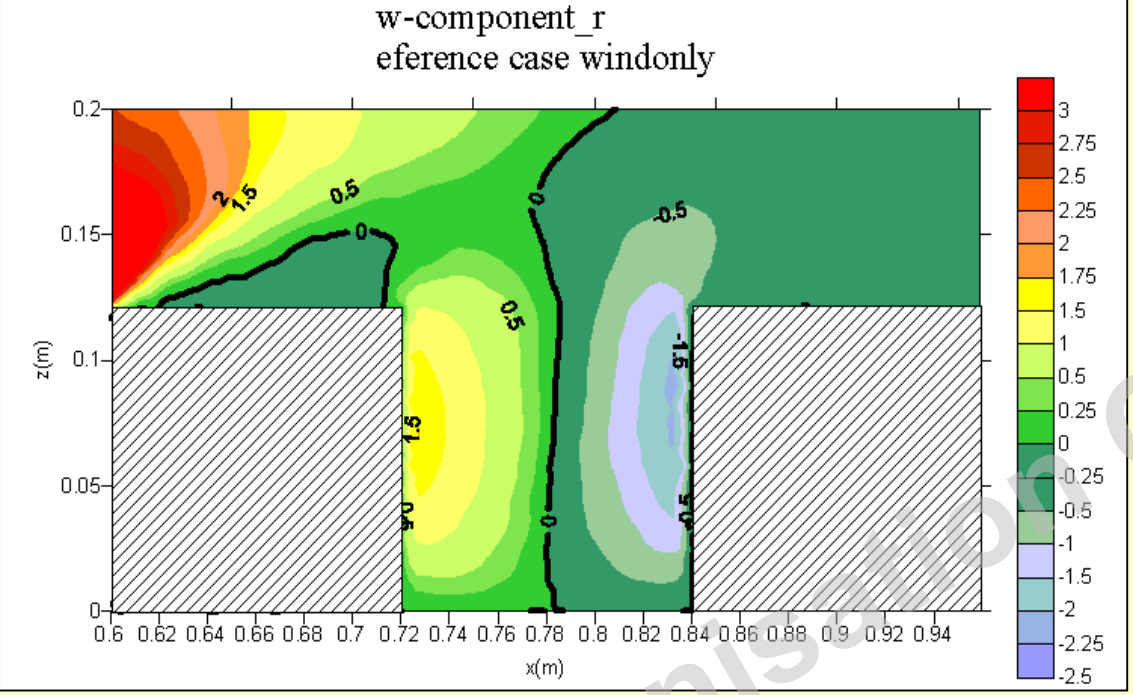

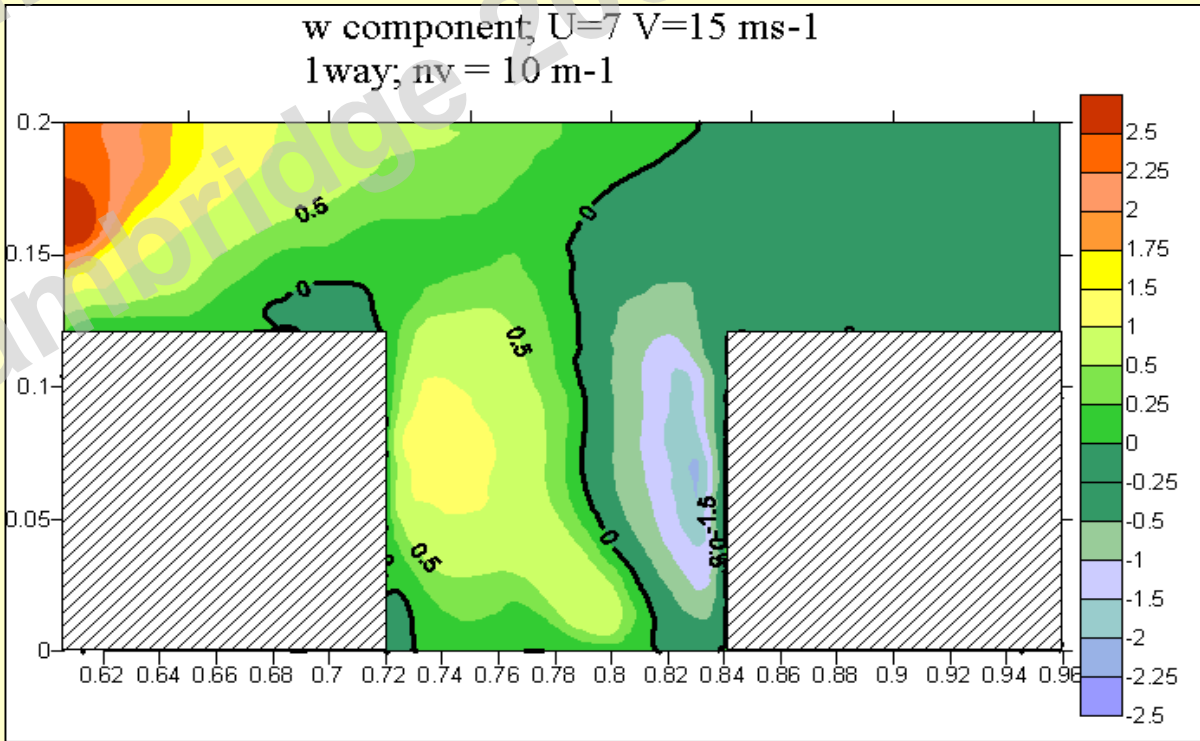

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