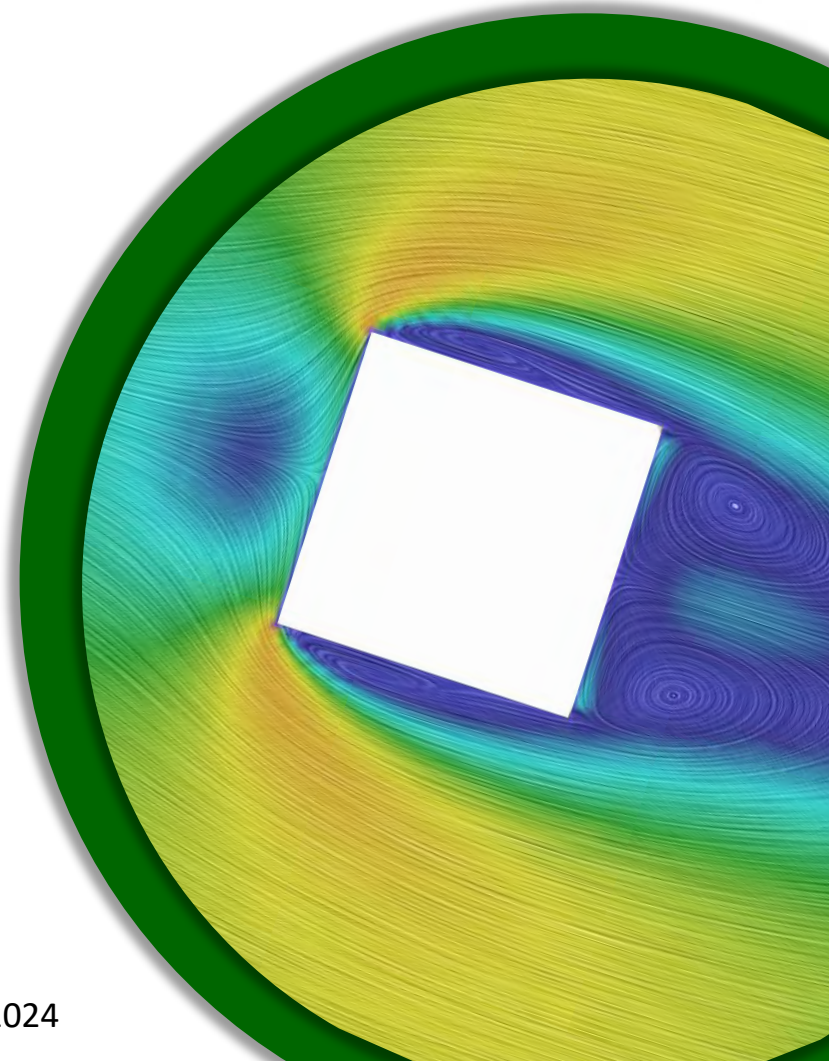
2024 FOAM@IBERIA

PASSIVE POLLUTANT DISPERSION VALIDATION TO WIND TUNNEL DATA



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Ferrol, 4 of October 2024

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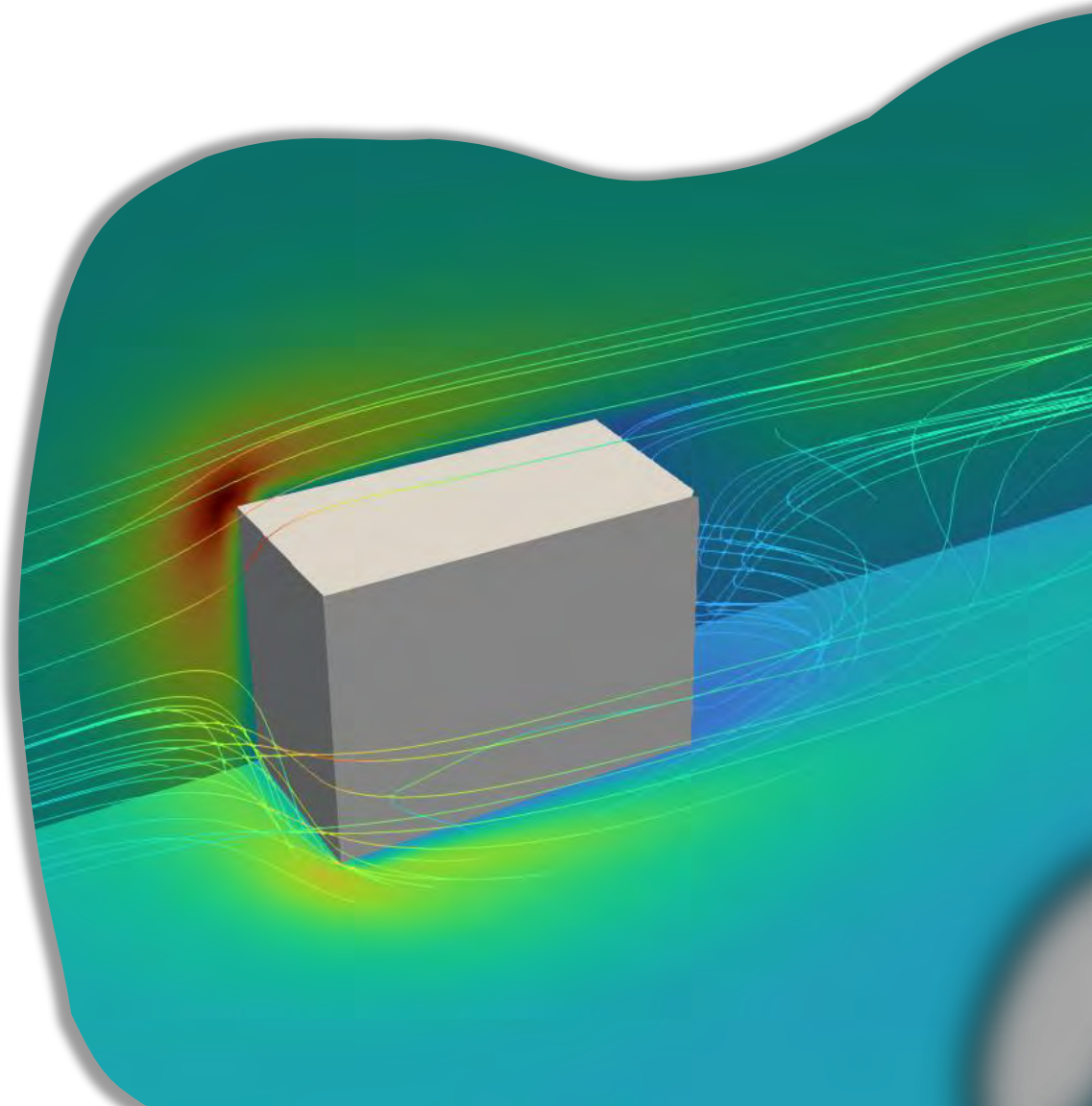
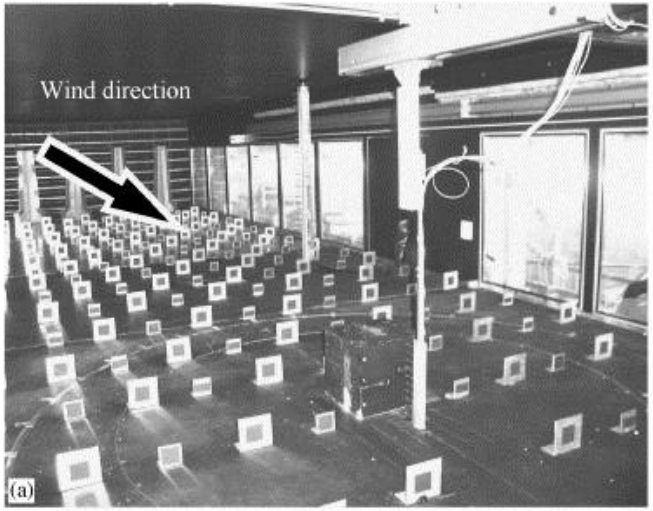


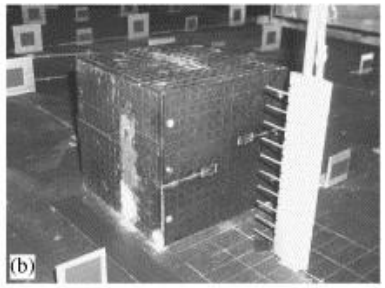
Introduction

- Objectives
  - Assess thermal interactions between an isolated heated building and wind flow dynamics.
  - Analyse pollutant dispersion from an emission source located within a building.
  - Validate the simulation results against respective wind tunnel experimental data.

ATREUS case setup

ATREUS Project → Wind tunnel experiments → CFD modelling

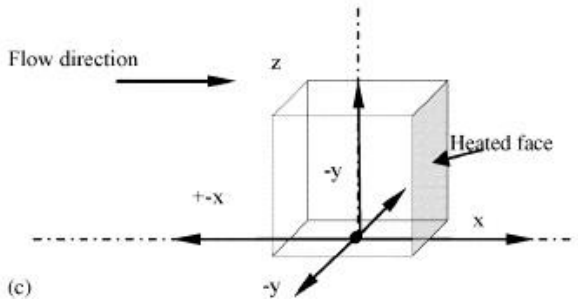




Experiments at the Meteorological Institute, University of Hamburg

$$Re = \frac{\rho V l}{\mu}$$

$$Gr = \frac{\beta g H \left(\bar{T}_{W-} \bar{T}_{ref}\right)}{v^2}$$



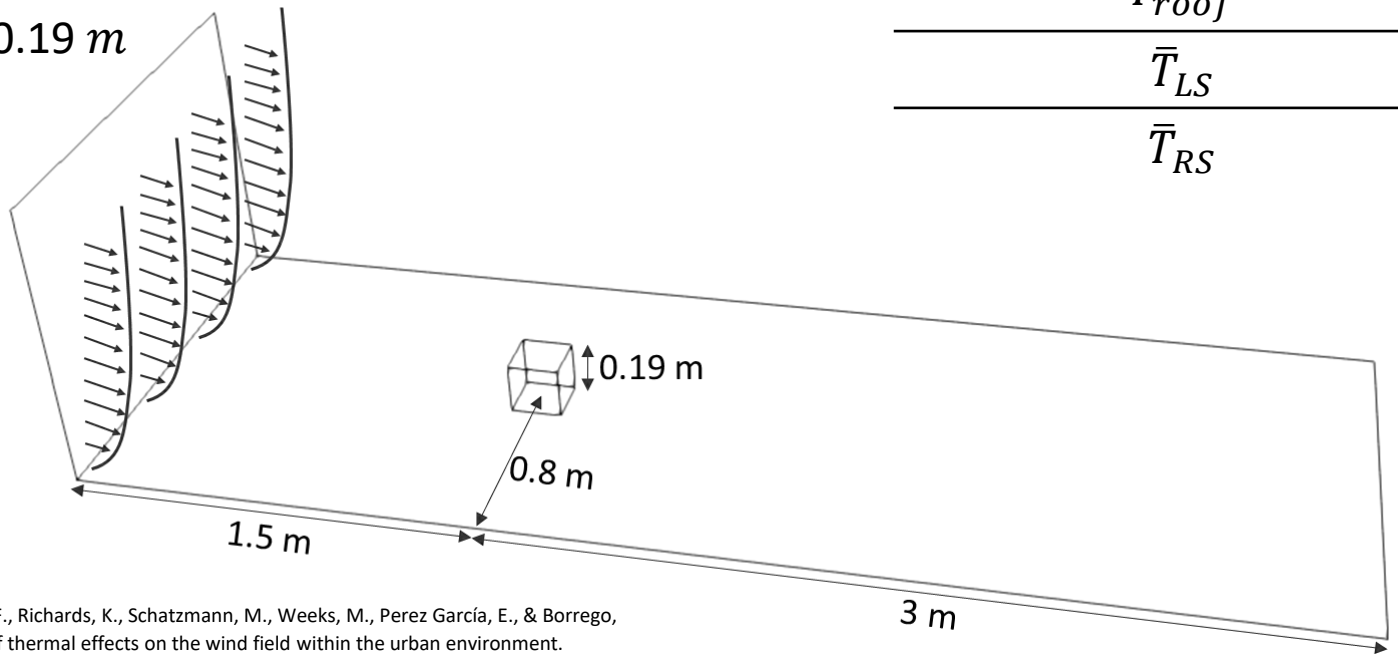
Richards, K., Schatzmann, M., & Leitl, B. (2006). Wind tunnel experiments modelling the thermal effects within the vicinity of a single block building with leeward wall heating. *Journal of Wind Engineering and Industrial Aerodynamics*, *94*(8), 621–636. https://doi.org/10.1016/j.jweia.2006.02.003

ATREUS case setup

Case conditions

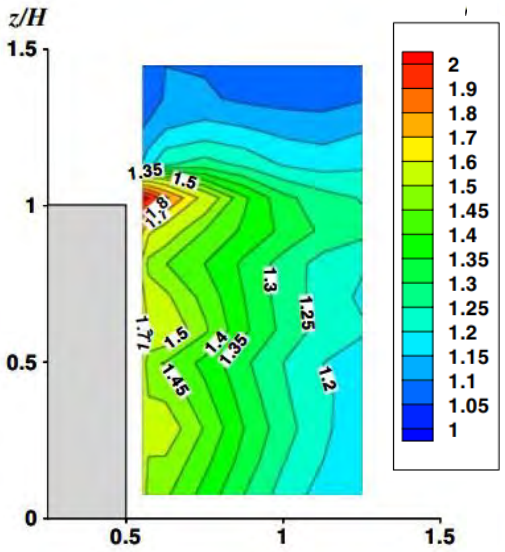
- Steady-state;
- buoyantSimpleFoam;
- k-ε turbulence model;
- Perfect gas equation of state;
- 528 324 cells (near-wall height 0.004 m);
- $U_{ref} = 1\ m/s$
- $Z_{ref} = 0.74\ m$
- H = 0.19 m

Thermal conditions at $\frac{Gr}{Re^2} \approx 1.6$	(°C)
$\bar{T}_W$	176
$\bar{T}_{ref}$	24
$\bar{T}_{floor}$	38
$\bar{T}_{roof}$	50
$\bar{T}_{LS}$	39
$\bar{T}_{RS}$	40

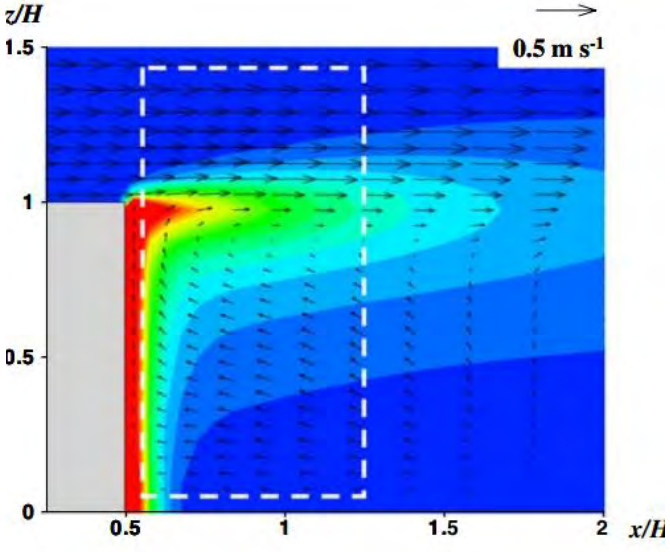


Dimitrova, R., Sini, J. F., Richards, K., Schatzmann, M., Weeks, M., Perez García, E., & Borrego, C. (2009). Influence of thermal effects on the wind field within the urban environment. *Boundary-Layer Meteorology*, *131*(2), 223–243. https://doi.org/10.1007/s10546-009-9368-4

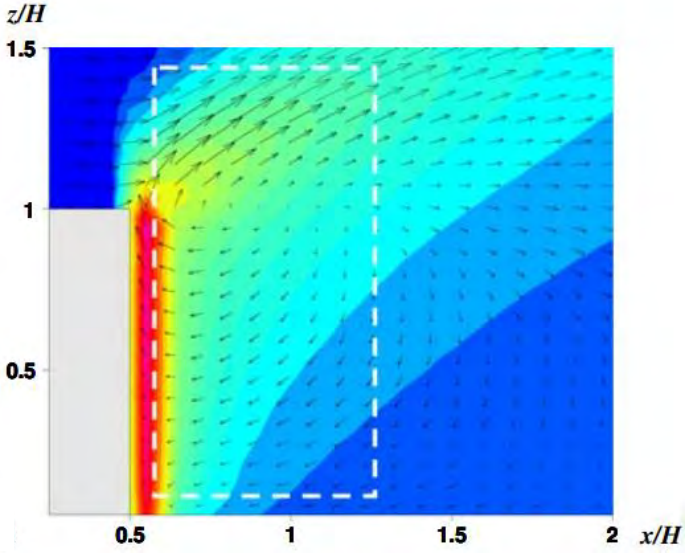
ATREUS case results



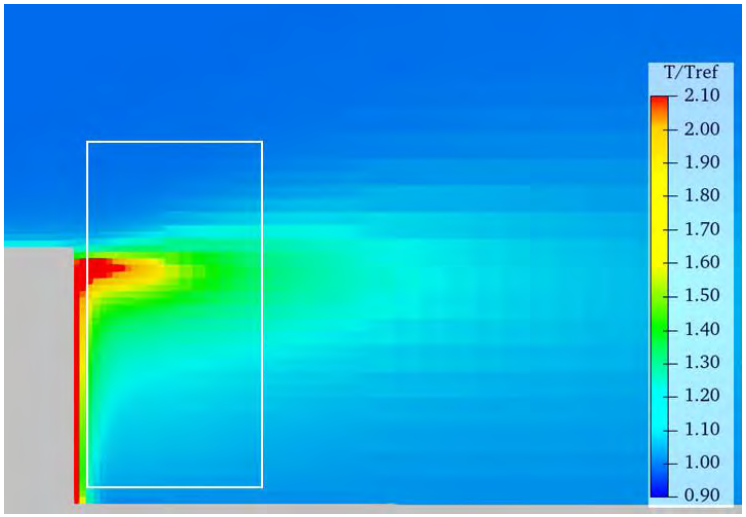
Wind Tunnel



CHENSI

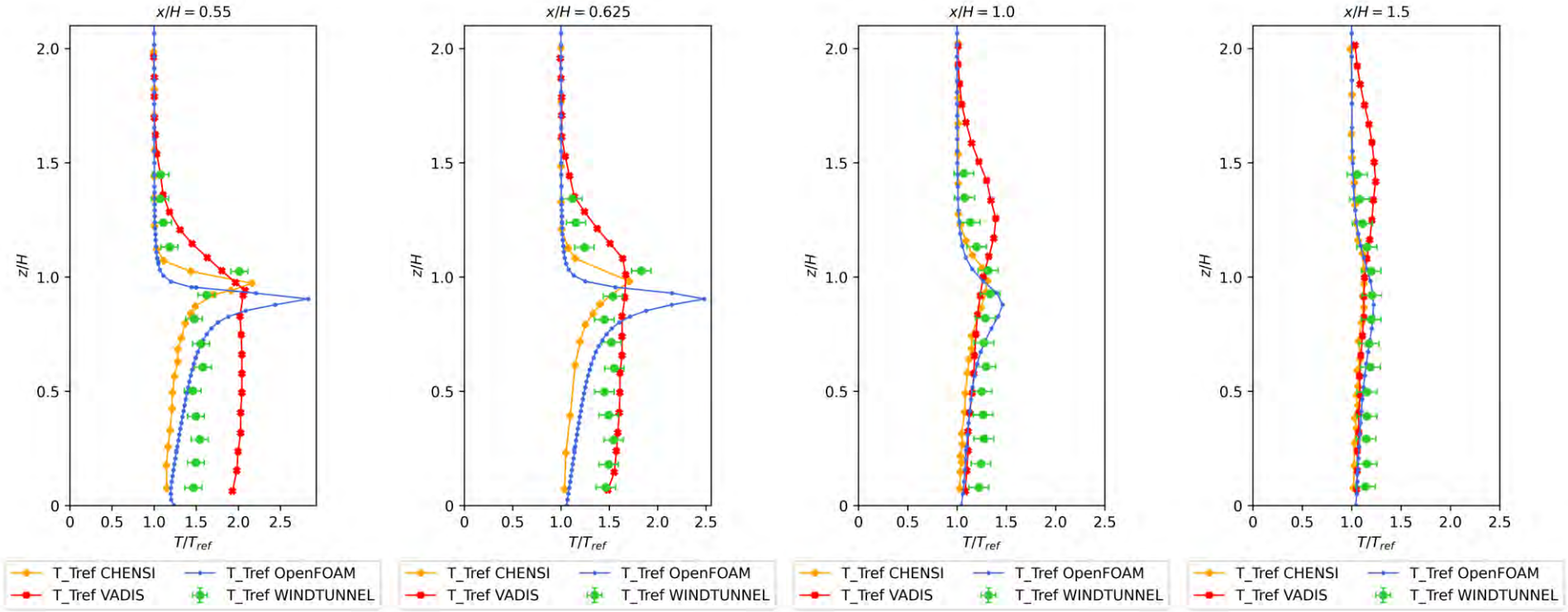


VADIS



OpenFOAM

ATREUS case results

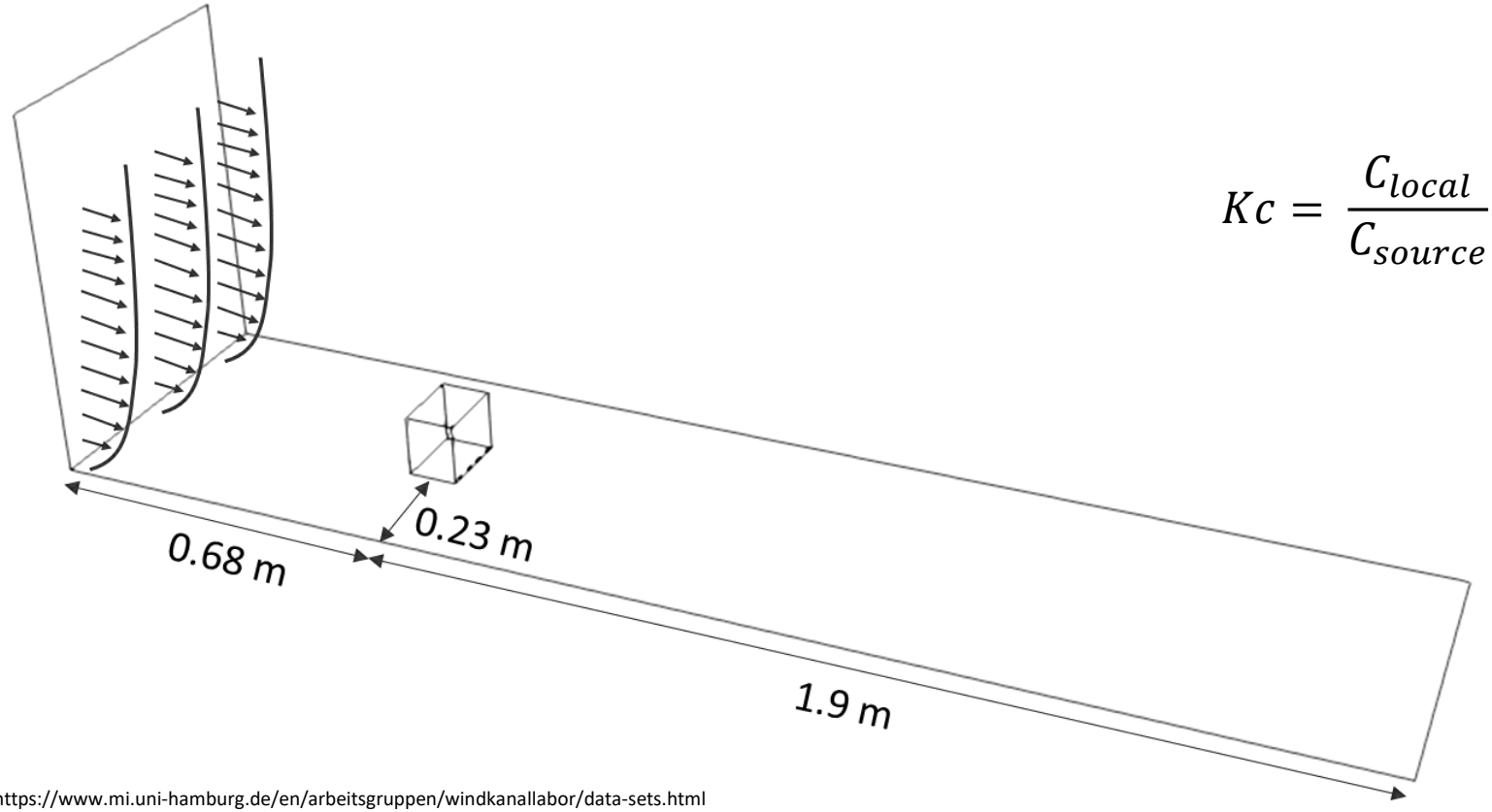


	x/H = 0.55			x/H = 0.65			x/H = 1.0			x/H = 1.5		
Validation metric	NME	MAE	RMSE	NME	MAE	RMSE	NME	MAE	RMSE	NME	MAE	RMSE
CHENSI	0.145	0.220	0.263	0.160	0.223	0.262	0.099	0.122	0.138	0.074	0.086	0.089
VADIS	0.192	0.281	0.347	0.083	0.108	0.122	0.100	0.117	0.135	0.076	0.085	0.096
OpenFOAM	0.153	0.231	0.330	0.185	0.267	0.320	0.086	0.103	0.111	0.046	0.051	0.056

CEDVAL case setup

CEDVAL Wind Tunnel Dataset → CFD modelling

Experiments at the Meteorological Institute, University of Hamburg



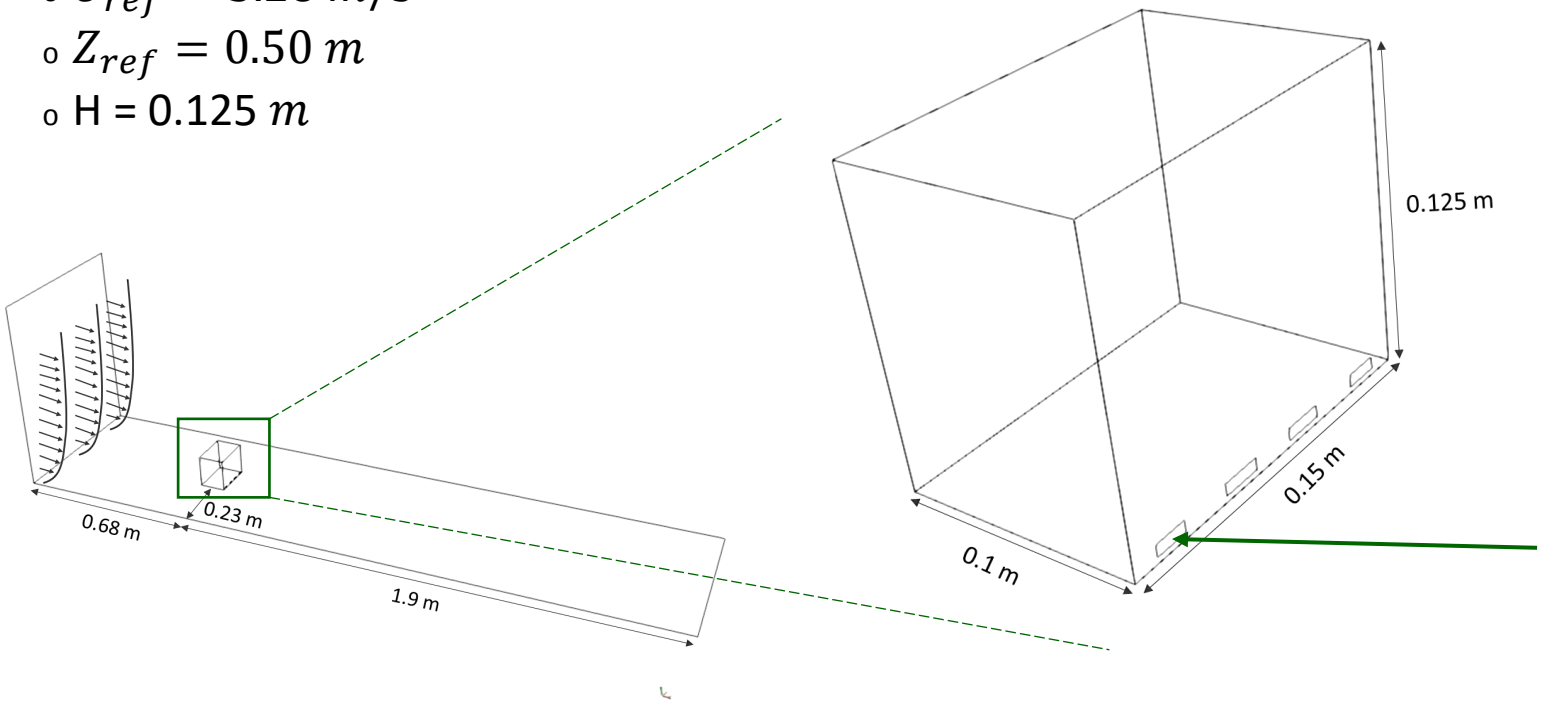
$$Kc = \frac{C_{local}}{C_{source}} \times \frac{U_{ref} H^2}{Q_{source}}$$

https://www.mi.uni-hamburg.de/en/arbeitsgruppen/windkanallabor/data-sets.html

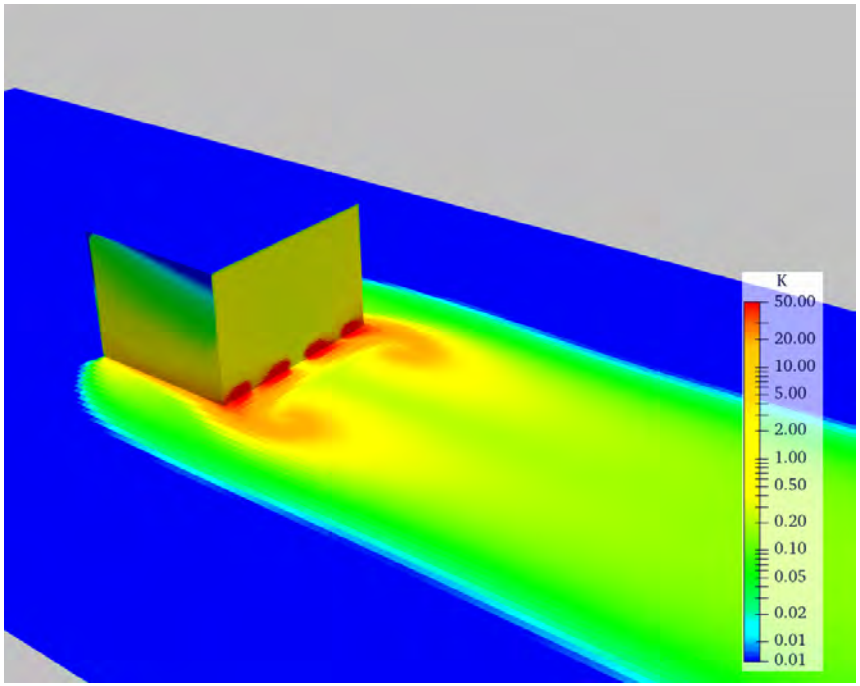
CEDVAL case setup

Case conditions

- Steady-state;
- SimpleFoam;
- k-ε turbulence model;
- Perfect gas equation of state;
- 2 640 062 cells (near-wall height 0.002 m);
- $U_{ref} = 5.28\ m/s$
- $Z_{ref} = 0.50\ m$
- H = 0.125 m
- scalarTransport
- Pollutant
- $U_{exaust} = 0.024\ m/s$
- $Q_{exaust} = 0.000011\ m^3/s$

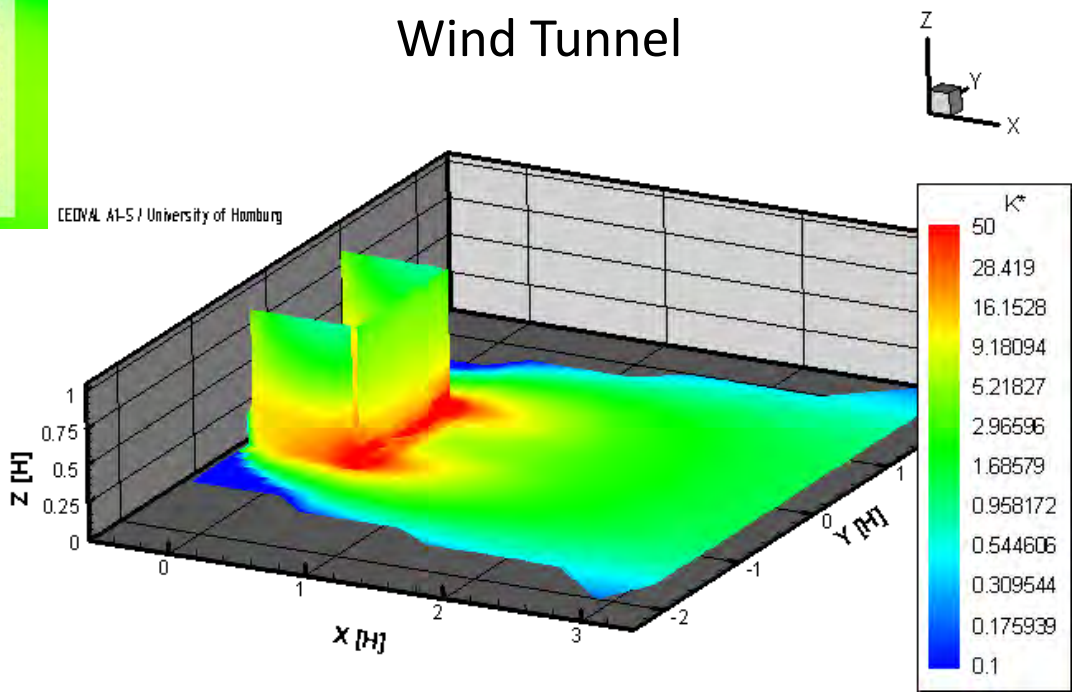


CEDVAL case results

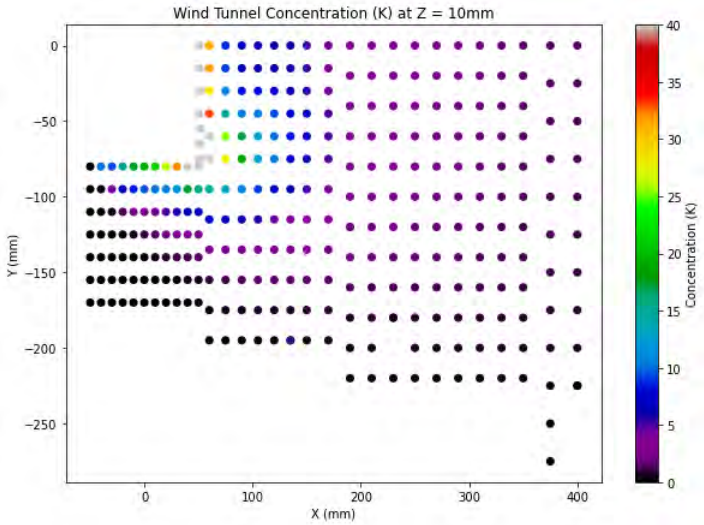


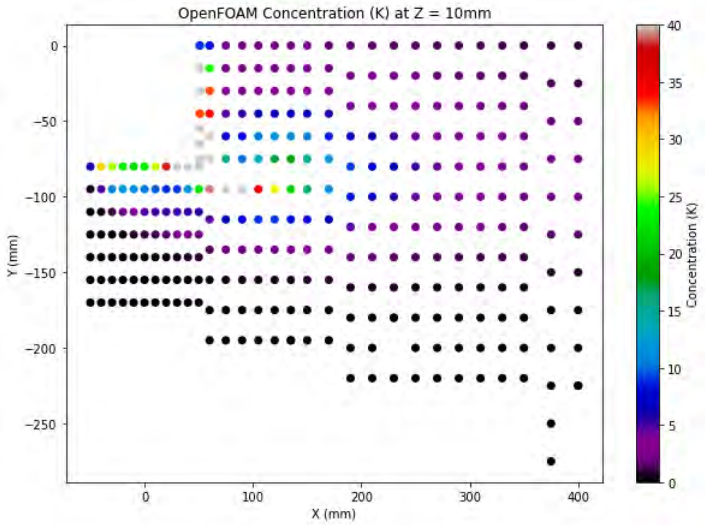
OpenFOAM

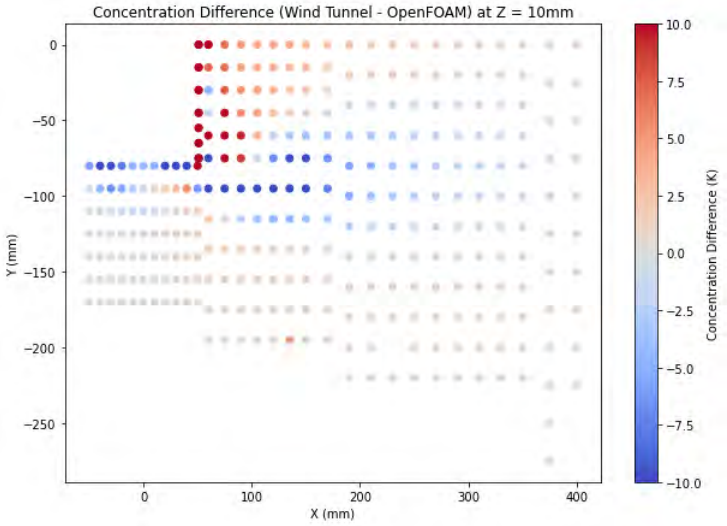
Wind Tunnel



CEDVAL case results







	Z = 0.10		
Validation metric	ACD	MAE	RMSE
OpenFOAM	5.05	8.52	25.66 about 7% range

Average Concentration Difference (ACD)

Conclusions/Next Steps

- Results show good agreement with experimental data, while highlighting opportunities for further refinement;
- Ongoing efforts will focus on validating the model in more complex scenarios;
- Future analysis will integrate both pollutant dispersion and urban thermal effects to enhance CFD results accuracy.

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Thank you!
Questions?

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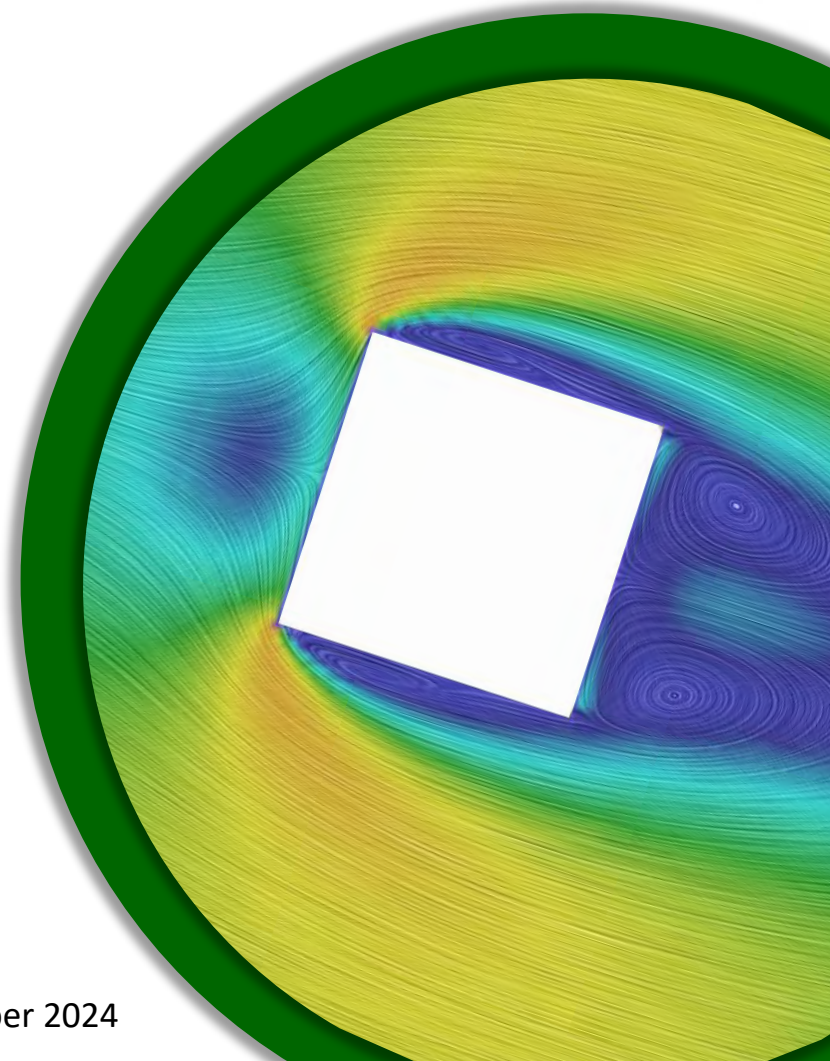

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Ferrol, 4 of October 2024