A CFD MODELING APPROACH FOR A CONTAMINANT RELEASED IN A CITY

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Motivation

Development of the realistic models to simulate atmospheric dispersion in urban environments both forward modelling and backtracking using the open source CFD: OpenFoam

Model setup

MUST experiment (by placing 120 shipping containers placed in a regular formation of 10 rows and 12 columns with 48 receptors points: Fig.1).

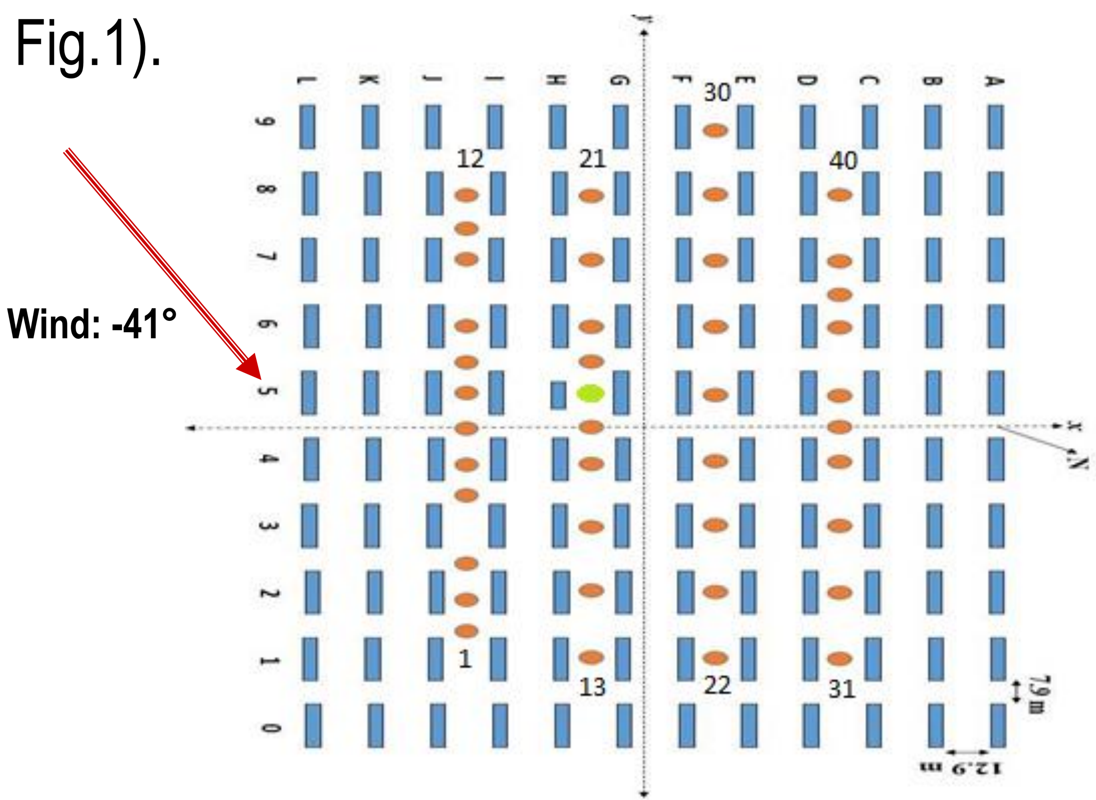


Figure 1:Representation of the MUST experiment with the location of measurement sensors

Numerical Method

Dispersion is modelled by the turbulent incompressible solver for RANS equations (for the flow field) coupled to the advection-diffusion equation (tracer gas). According to the type of simulation modelling, direct or inverse, this equation can be defined in each case for the mean concentration C as follows:

$$\begin{cases} \dfrac{\partial C}{\partial t} + U_i \dfrac{\partial C}{\partial x_i} - \dfrac{1}{\rho}\dfrac{\partial}{\partial x_i}\left(\rho K \dfrac{\partial C}{\partial x_i}\right) = S & (Direct : Transport\ Equation) \\ -\dfrac{\partial C^*}{\partial t} - U_i \dfrac{\partial C^*}{\partial x_i} - \dfrac{1}{\rho}\dfrac{\partial}{\partial x_i}\left(\rho K \dfrac{\partial C^*}{\partial x_i}\right) = S^* & (Inverse : Adjo\int Transport\ Equation) \end{cases}$$

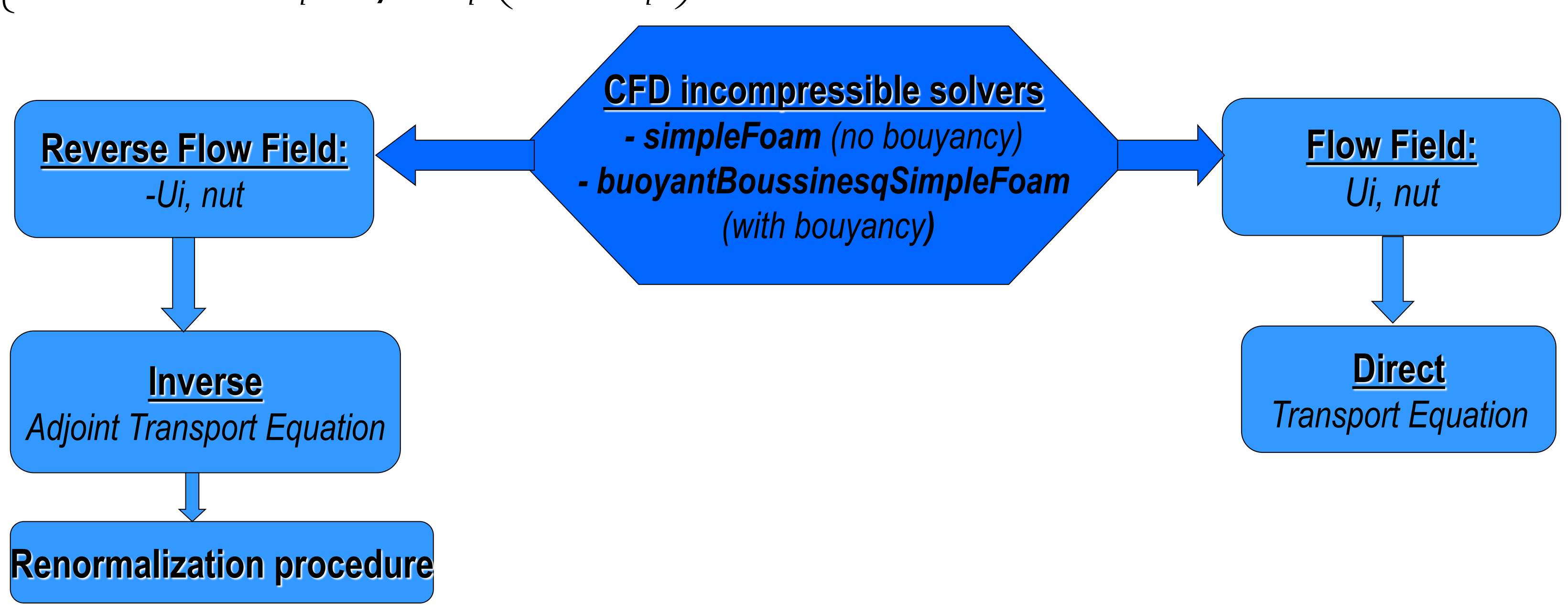


***Figure 2:** Schematic view of the numerical coupling in the direct and inverse dispersion problem* using OpenFoam solvers

The grid is generated by the OpenFoam snappyHexMesh mesher (Fig.3).

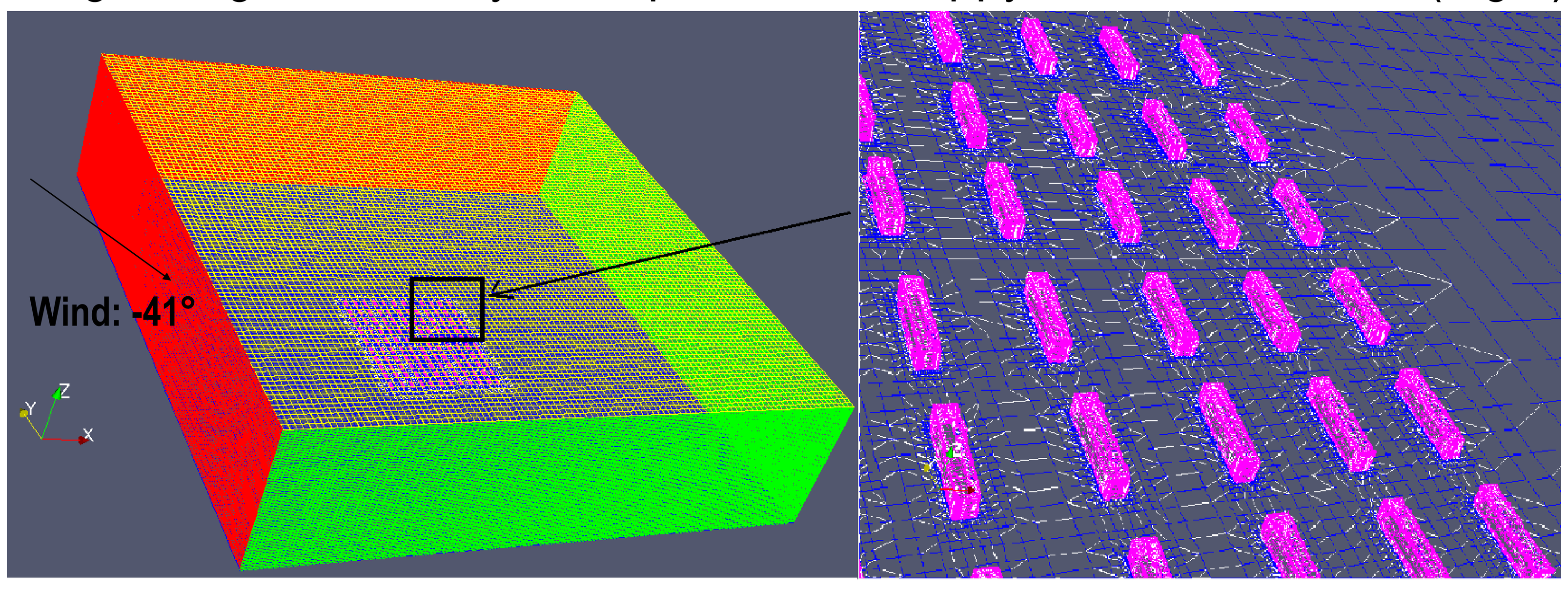


***Figure 3:** Site features and generating mesh using snappyHexMesh utility*

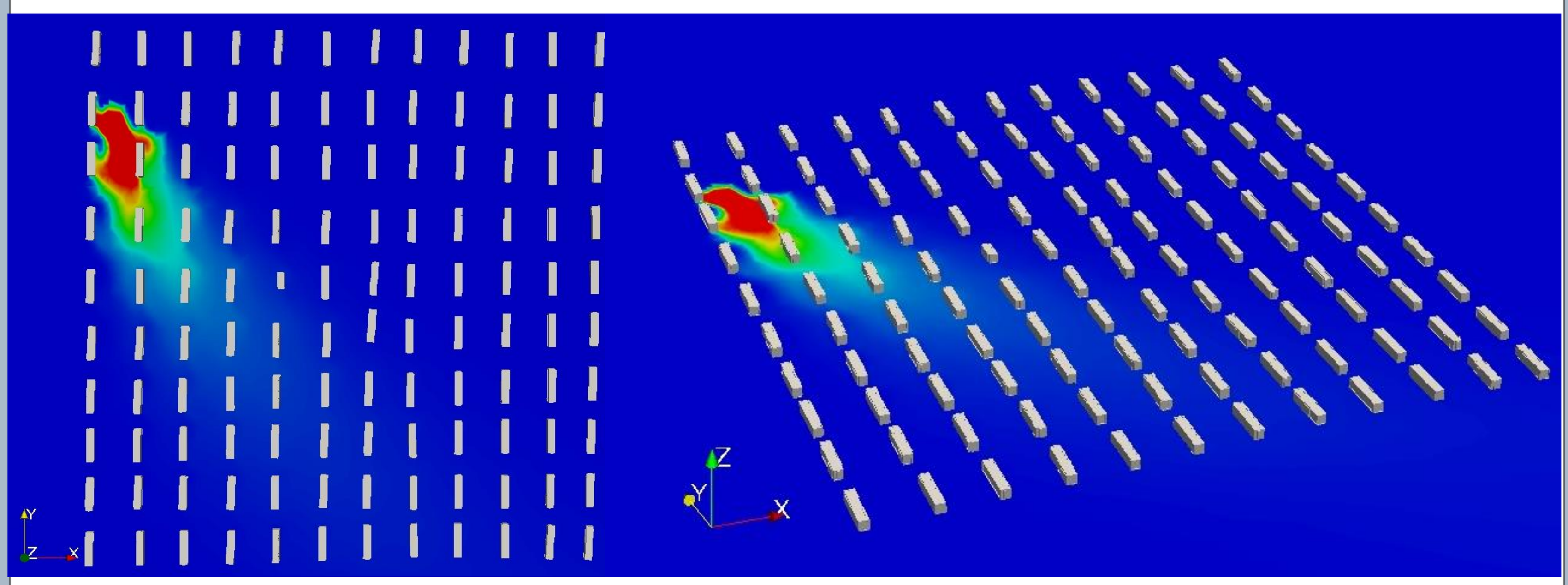
Boundary conditions:

Wind inflow at inlet, outflow at outlet, no slip solid surfaces at wall and symmetry condition at top of the computational domain.

Table 1: Characteristics of the test case #2681829

U (m s^{-1})	α (deg)	σ_θ (deg)	k (m^2 s^{-2})	Q (L min^{-1})	z_s (m)	u^* (m s^{-1})	L (m)	ε (m^2 s^{-3})
7.93	-41	9.5	1.46	225	1.8	1.1	28000	0.8

Results



a) 2D **b) 3D**

Figure 4: Ground level concentration contours computed from steady CFD solution

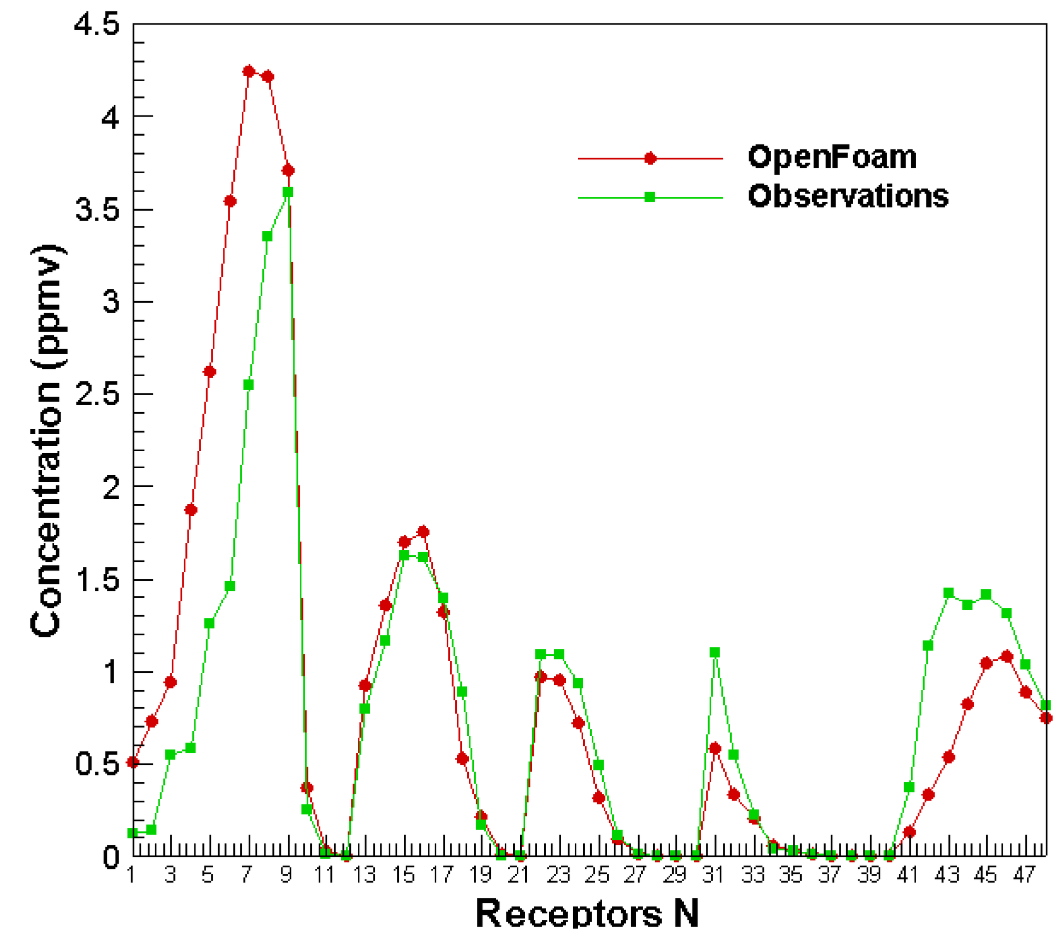
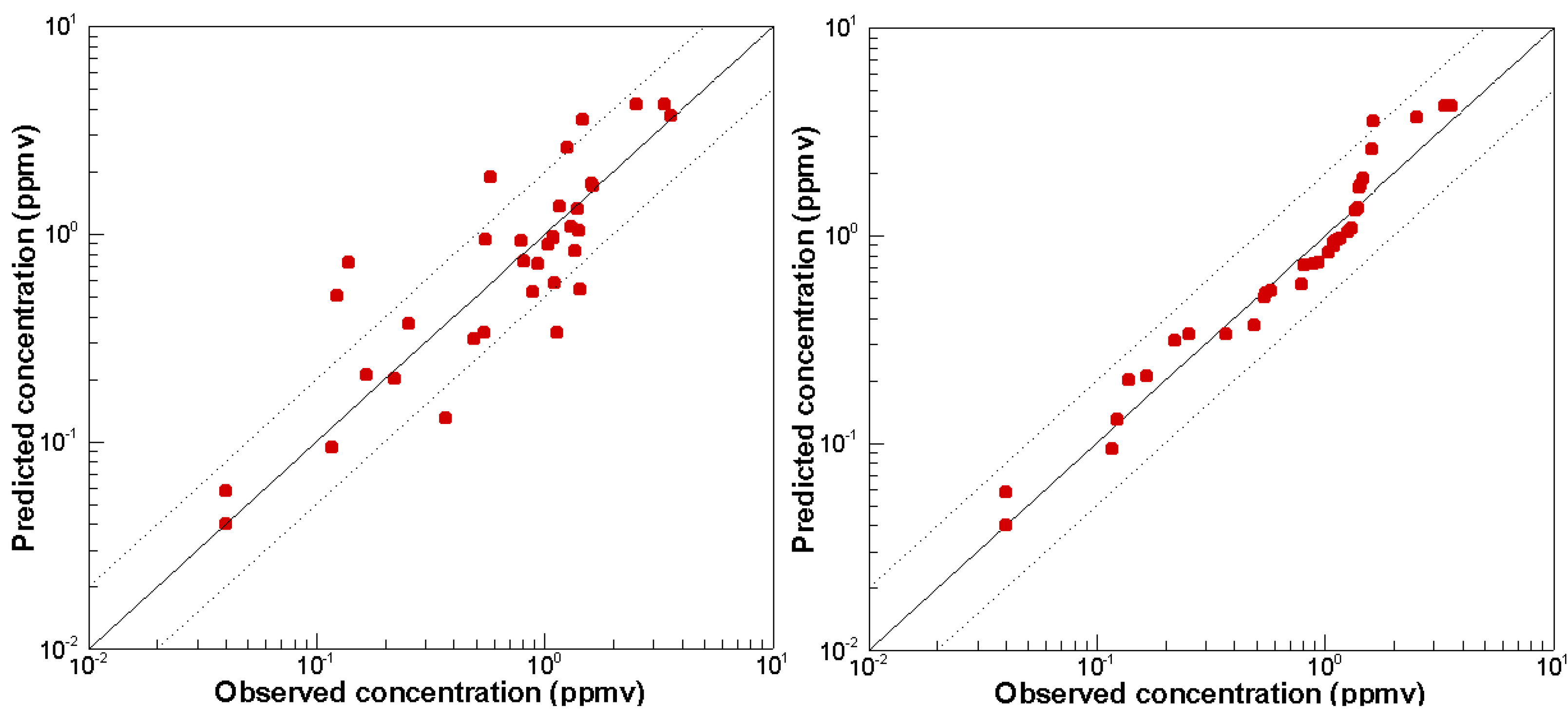


Figure 5: C_3H_6 concentration (in ppmv) at each sensor



a) **b)**

Figure 6: (a) Scatter and (b) quantile-quantile (Q-Q) plots between the predicted and observed average concentrations.

We can see from figures 5 and 6 that the CFD model predicts 83% of the total concentrations within a factor of two and shows the over-prediction tendency at the receptors near to the source but under-prediction at far away from the source. In general, the simulated concentrations by the CFD model have relatively good agreement with the observations.

Conclusion

- This first comparison shows an adequate agreement between the modelled values and the measured concentrations.
- The model has been coupled in inverse mode, based on renormalization theory for identifying a point source release in an urban like environment of MUST field experiment. The study is underway to highlight the detection feasibility of an unknown releases in real situations at an urban scale.

References

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