POLLUTANT DISPERSION IN DEEP STREET CANYONS COMPARISON BETWEEN CFD AND OPERATIONAL MODEL SIMULATIONS

G. Favale* and *F. Murena
Chemical Engineering Department - University of Naples "Federico II" Italy

Sotiris Vardoulakis
London School of Hygiene and Tropical Medicine

Efisio Solazzo
University of Birmingham

Overview

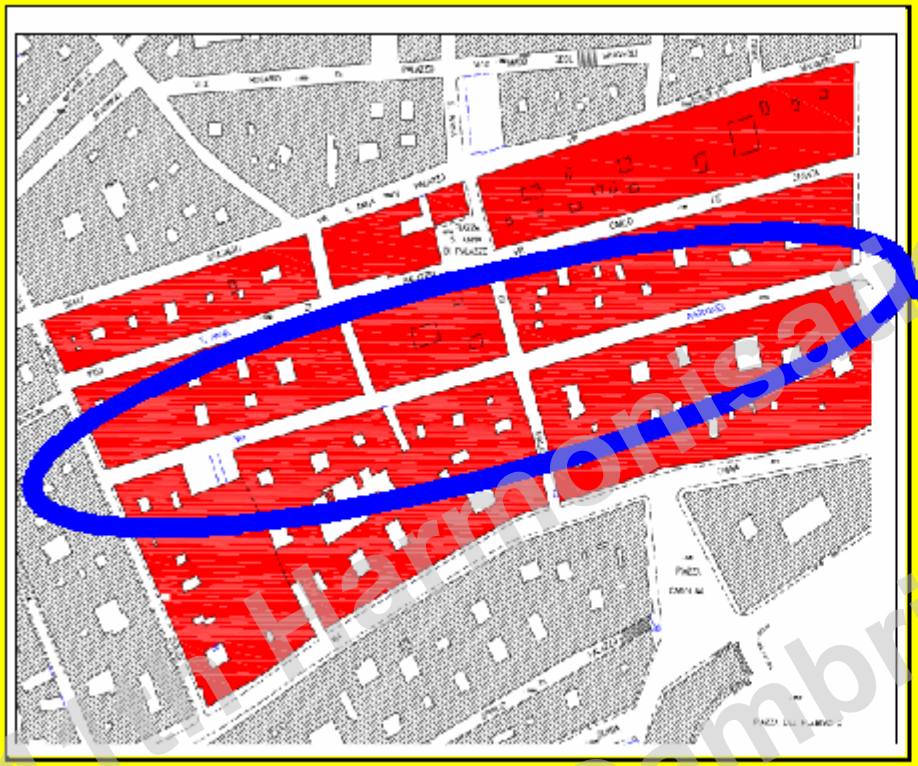
- Monitoring campaign in Naples
- CFD simulations
- Operational dispersion modelling

Can regulatory dispersion models be used in cases of deep street canyons?

- 1 million inhabitants
- 110 km^2
- density 9000 km^{-2}

- Cars 550,000
- 2-wheels 230,000
- Bus 3,000
- Total ≈ 800,000 vehicles

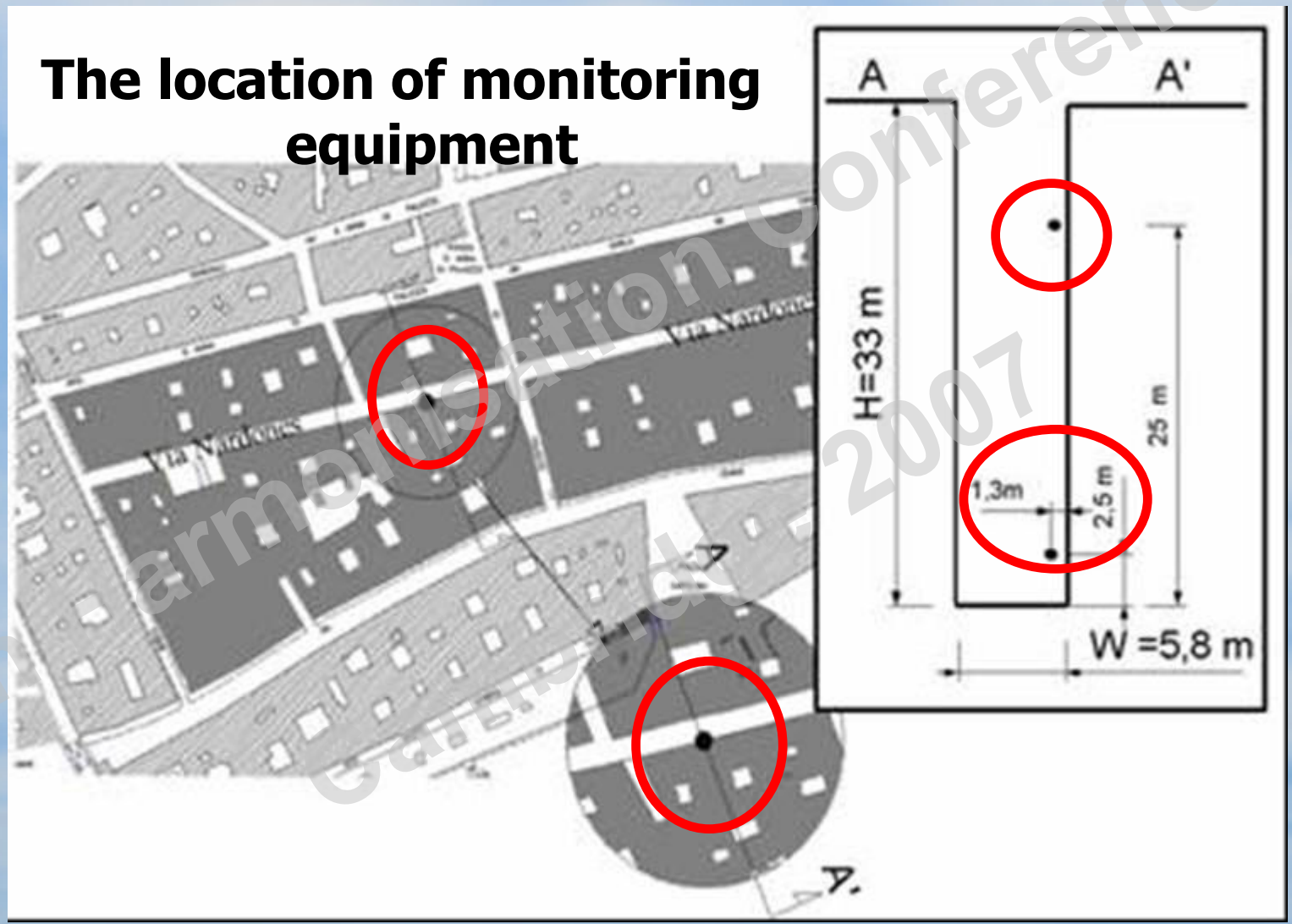
Deep street canyon



Width = 5.8 m
Height = 33 m
Length ≈ 300 m

(Aspect Ratio H/W = 5.7)

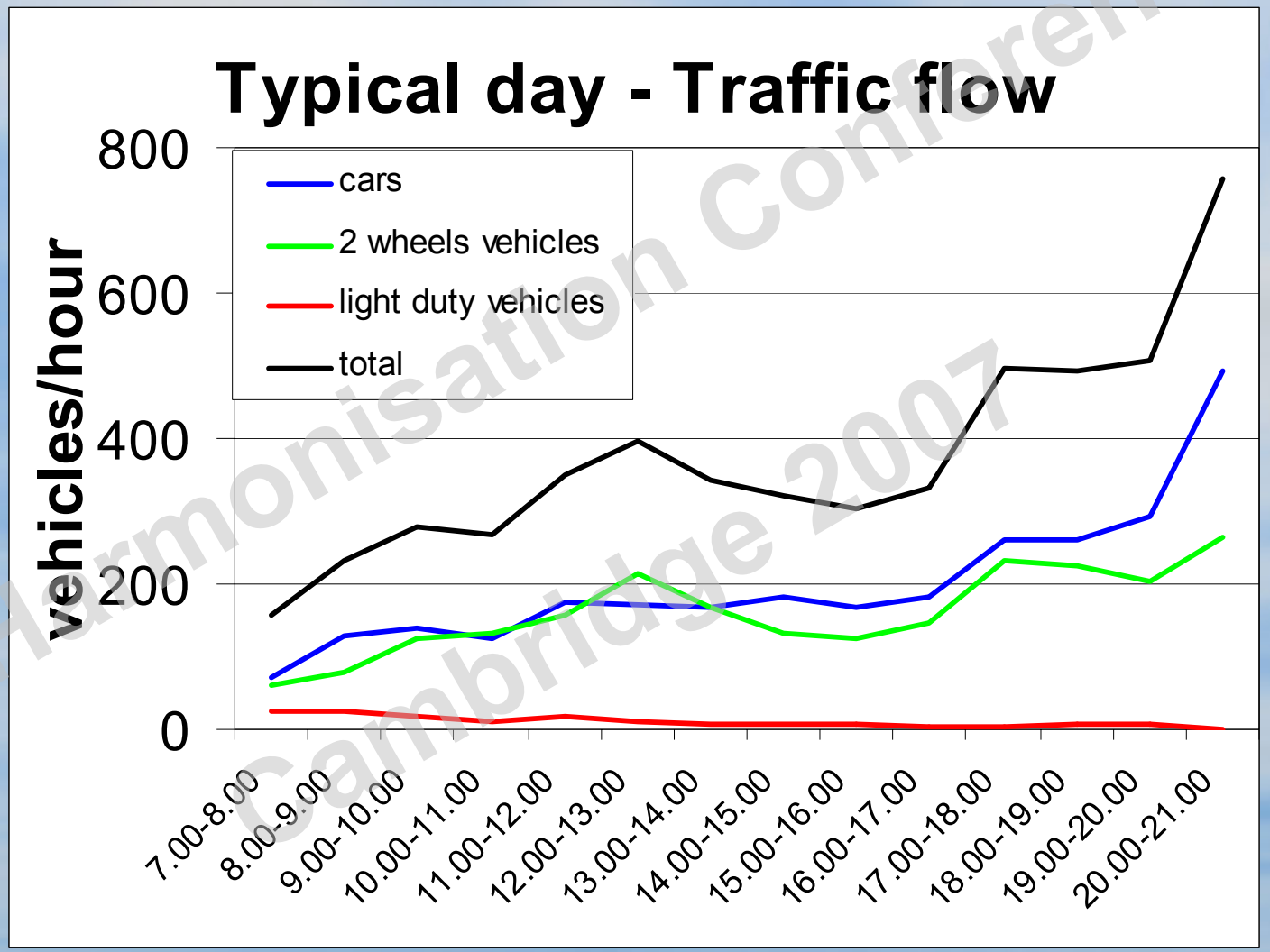
The location of monitoring equipment



The Monitoring Campaign

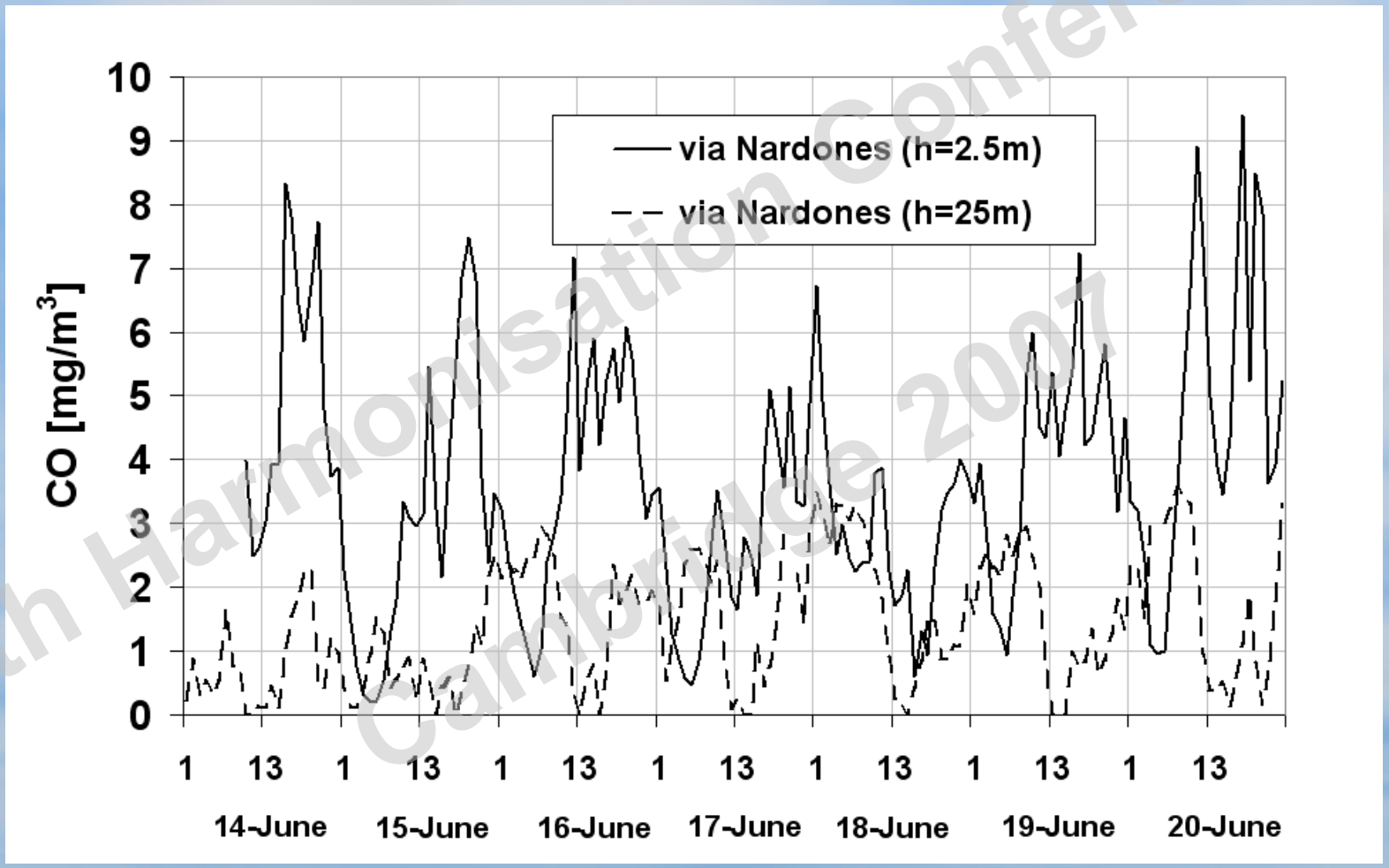
From 14 to 20 June 2006

- **CO at h=2.5 and 25 m in via Nardones**
- **Traffic flow in the street canyon**
- **Meteo parameters at roof top level**
- **Bacground CO from air quality monitoring stations**



CO Monitoring Results

H=2.5 m vs H=25 m



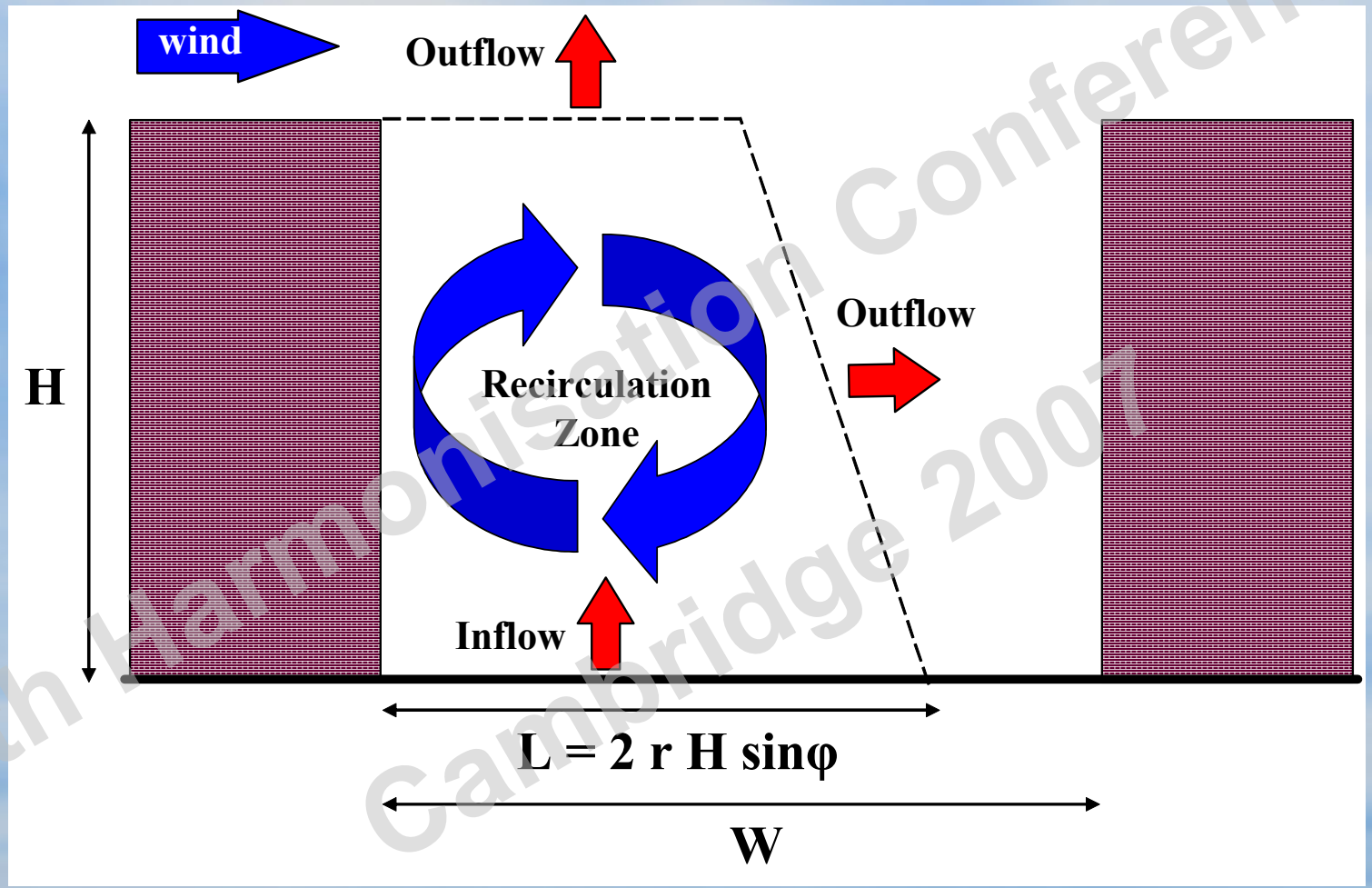
Modelling

- **FLUENT** (CFD model)
  Better understanding of processes

- **WinOSPM** (operational dispersion model)
  Regulatory street canyon applications
  Mainly validated for regular (and wide) canyons

Traffic induced turbulence not included in simulations

WinOSPM



$$C_{Total} = C_D + C_R + C_B$$

FLUENT

input and operating conditions

INPUT →

- Hourly average wind speed and wind direction
- Hourly CO vehicular emission rate in street canyon
- Wind inflow velocity profile approximated using a power law relationship
- CO input from road surface with constant vertical velocity

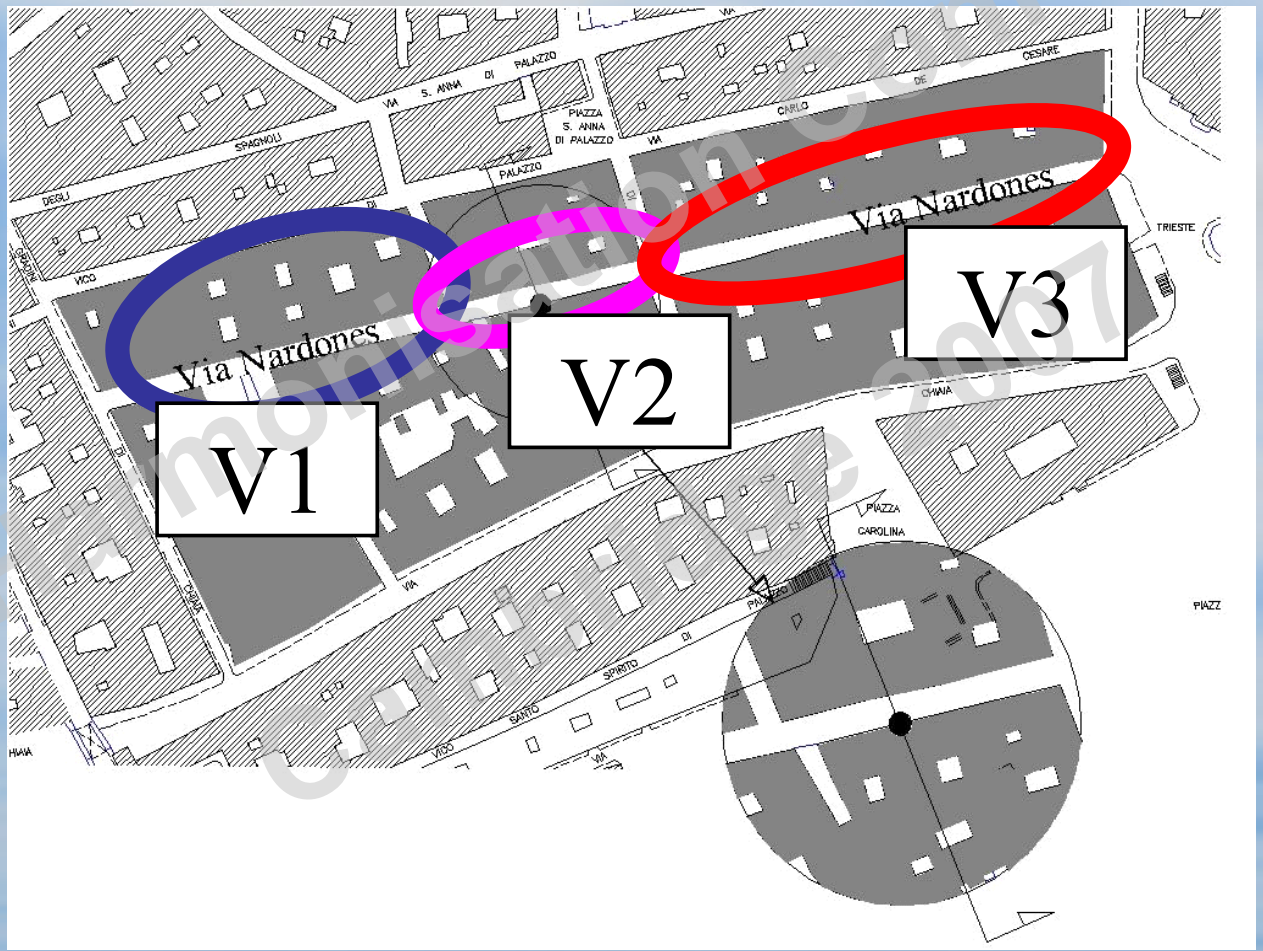
OPERATING CONDITIONS →

- Unsteady RANS model
- k-ε RNG turbulent closure method

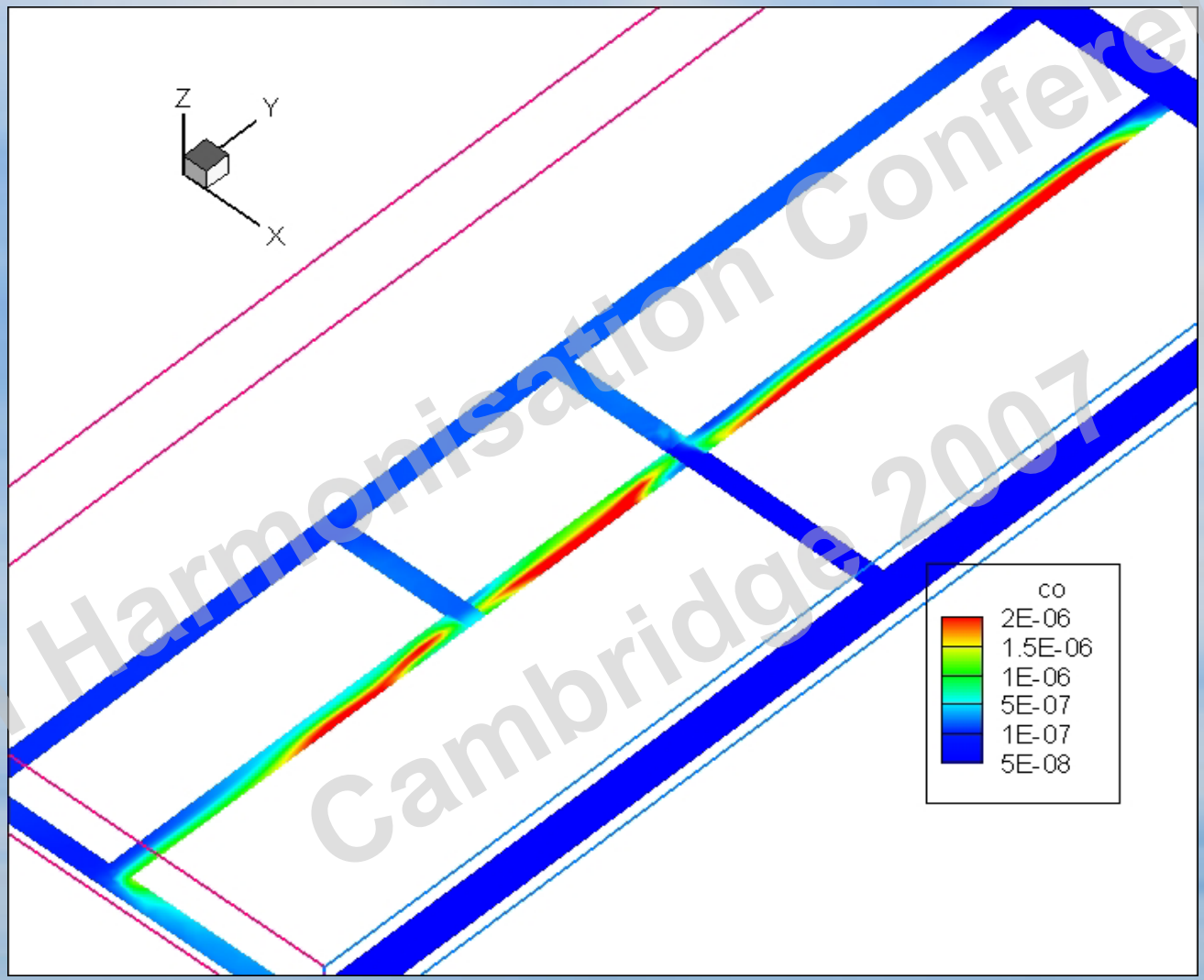
- 6 sub volumes
- 3 bottom volumes (0 - 4 m)
- 3 upper volumes (4 m - roof top)

FLUENT

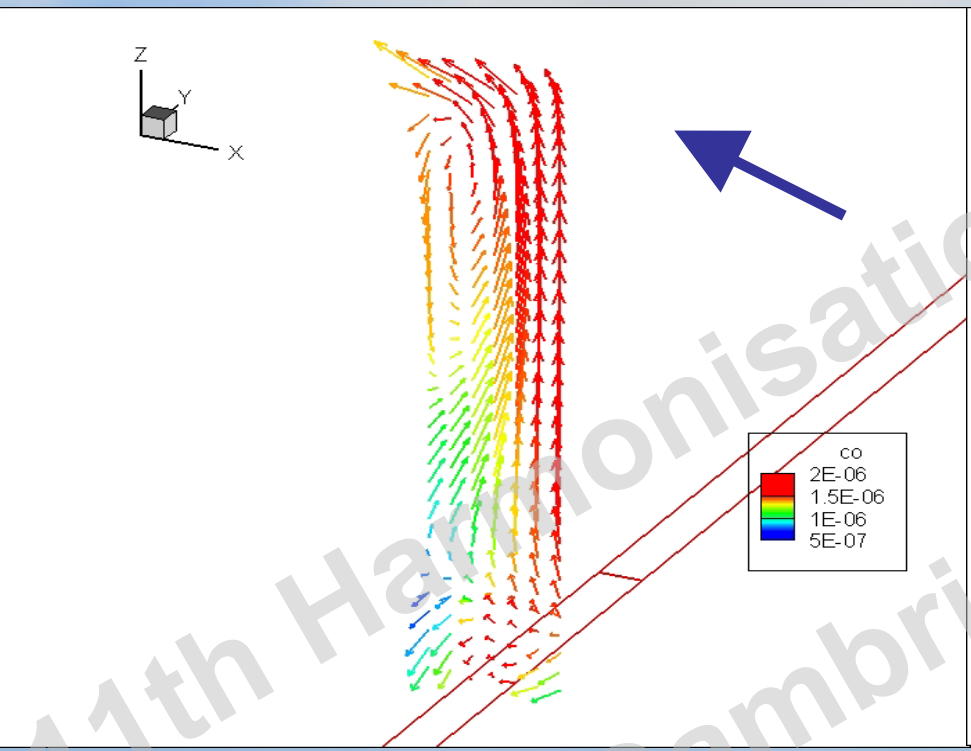
Sub volumes along axis length

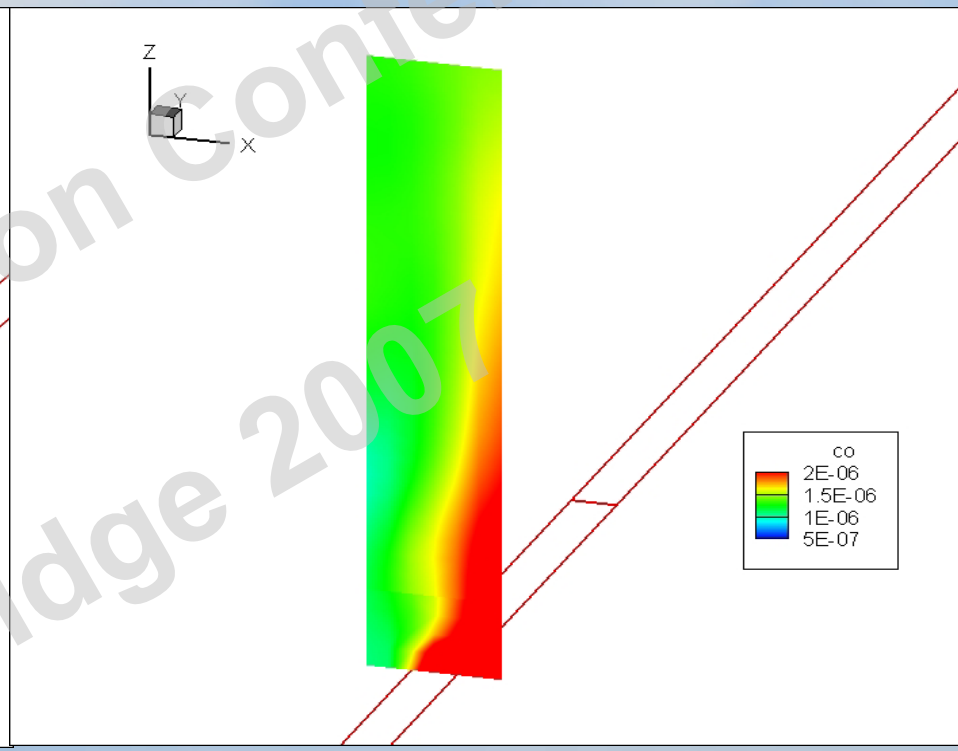


CO Distribution at Street Level



Wind flow and CO distribution

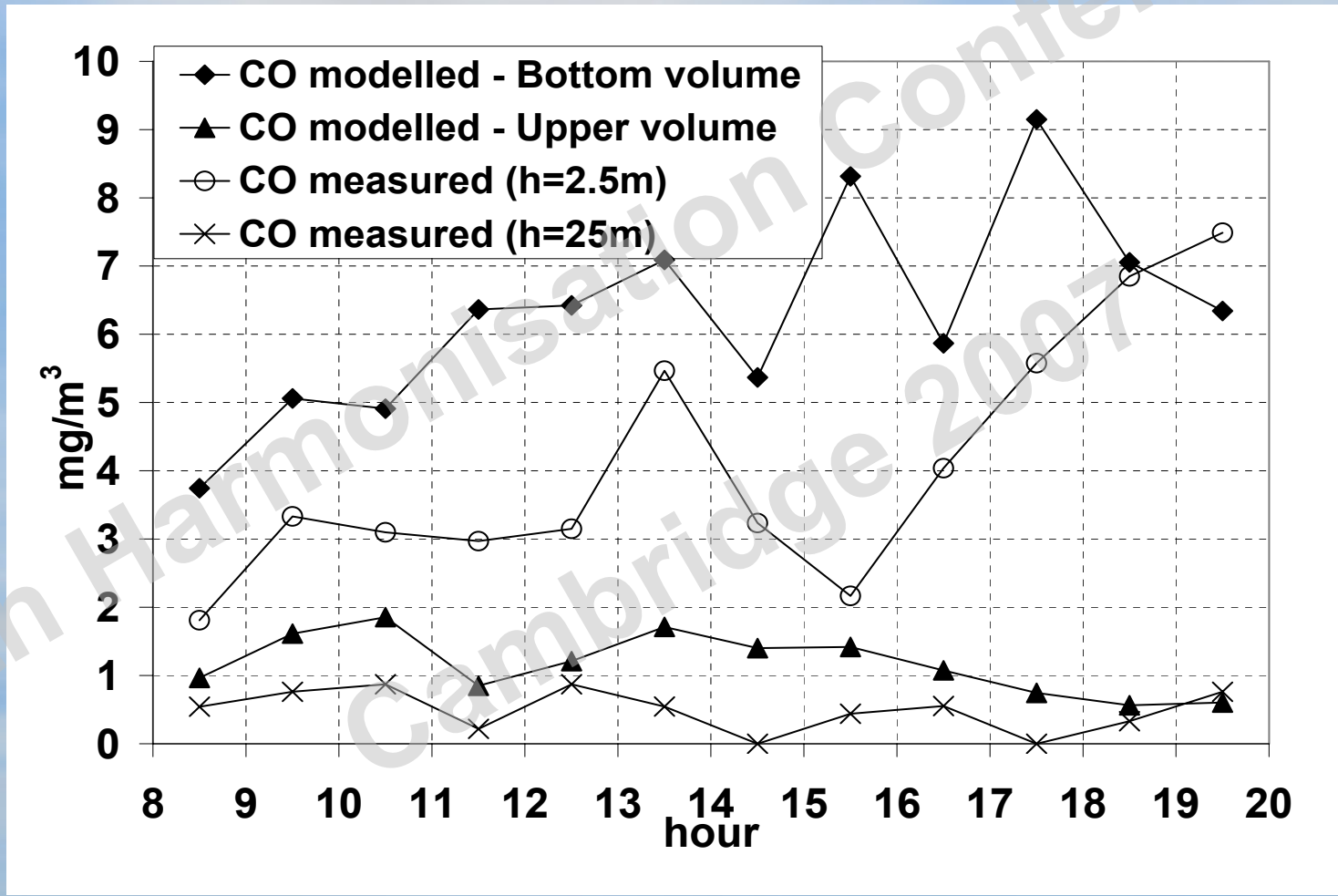




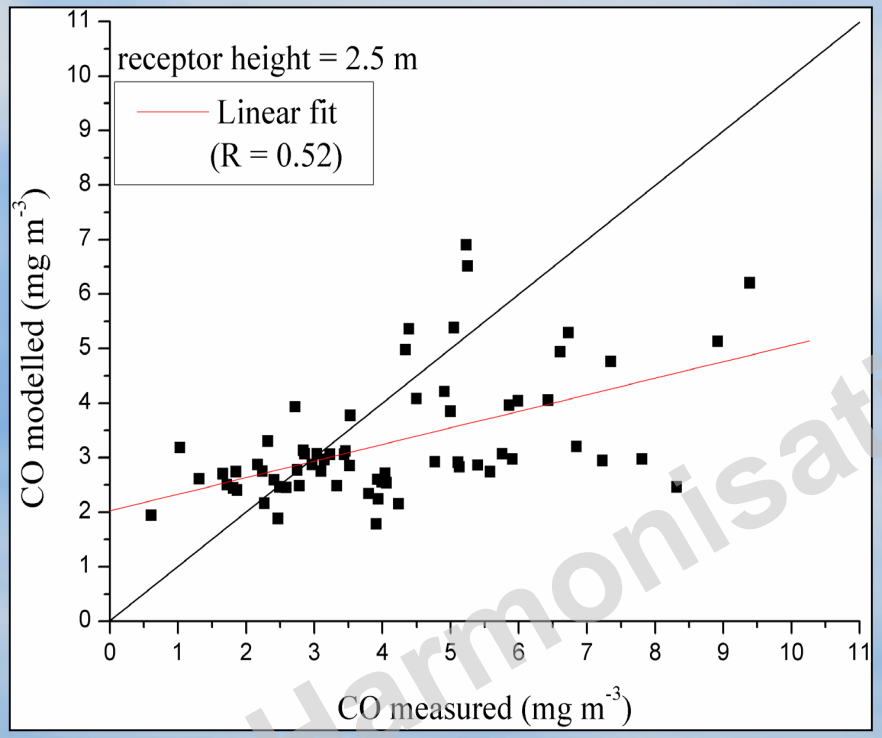
FLUENT: CO concentration

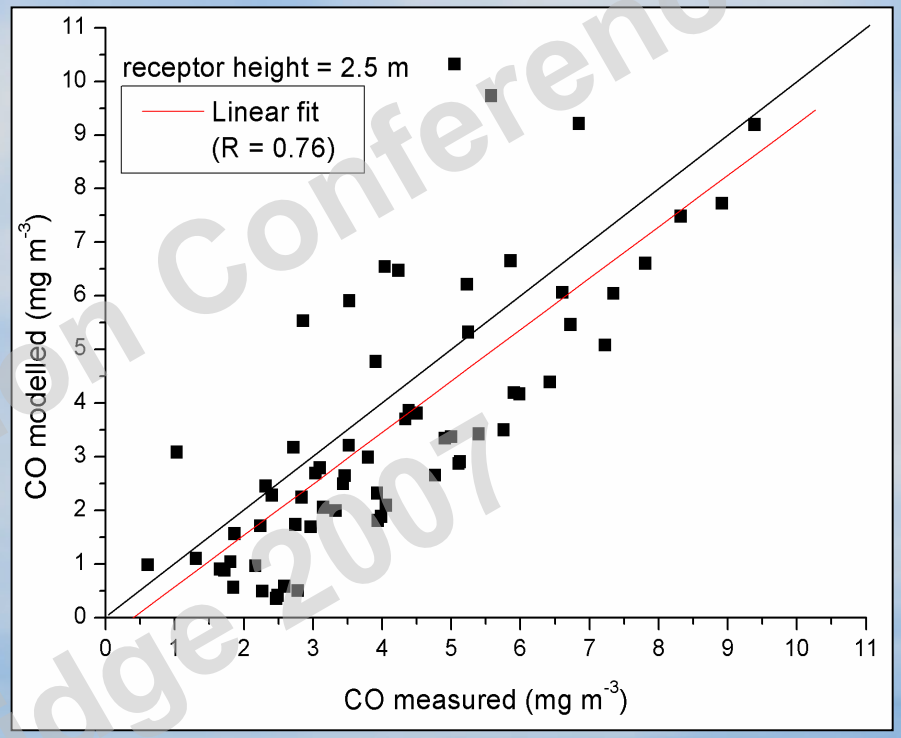
Bottom volume (from z=0 to z=4 m)

Upper volume (from z=4 m to roof top)



WinOSPM: CO concentrations

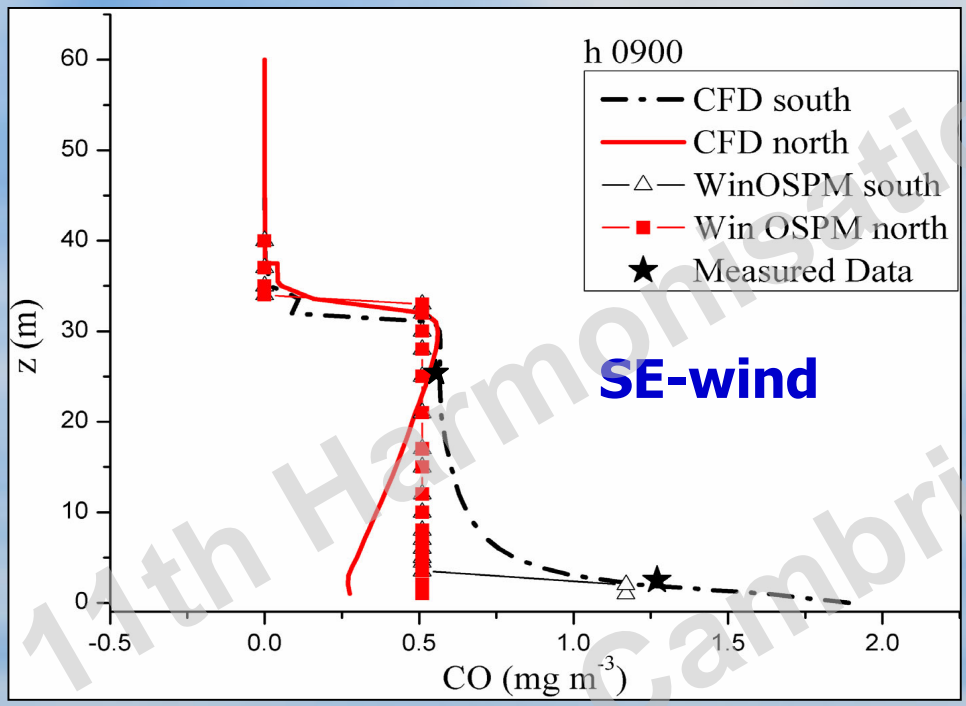


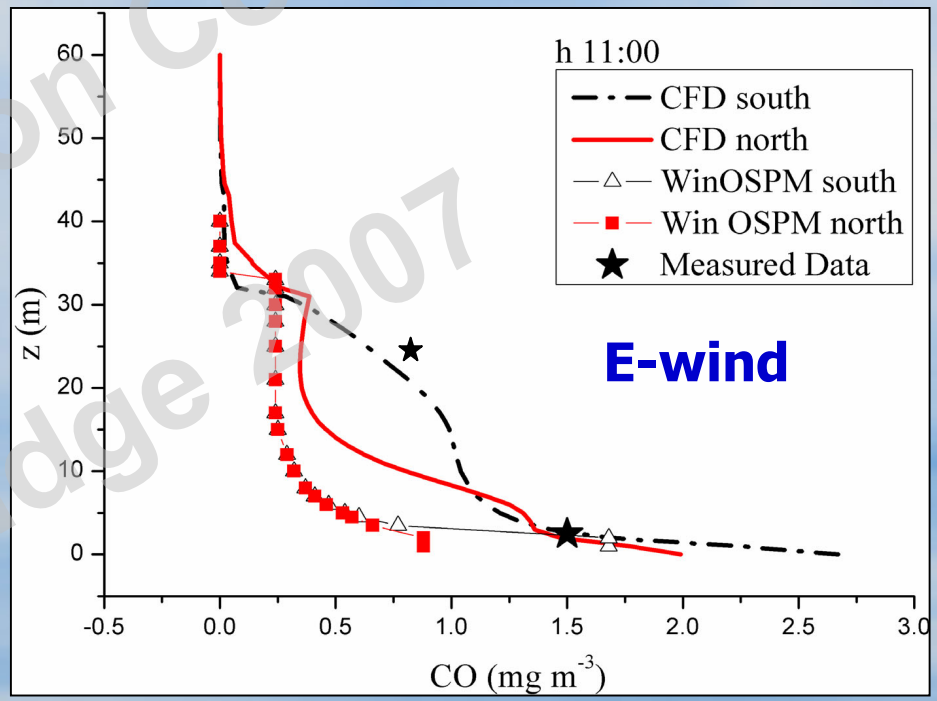


- **Observations showed that the wind at roof level and concentrations at street level were weakly correlated.**
- **CFD simulations suggested that wind speed at street level was reduced by almost a factor of 10, with respect to the default WinOSPM reduction factor.**

WinOSPM and FLUENT:

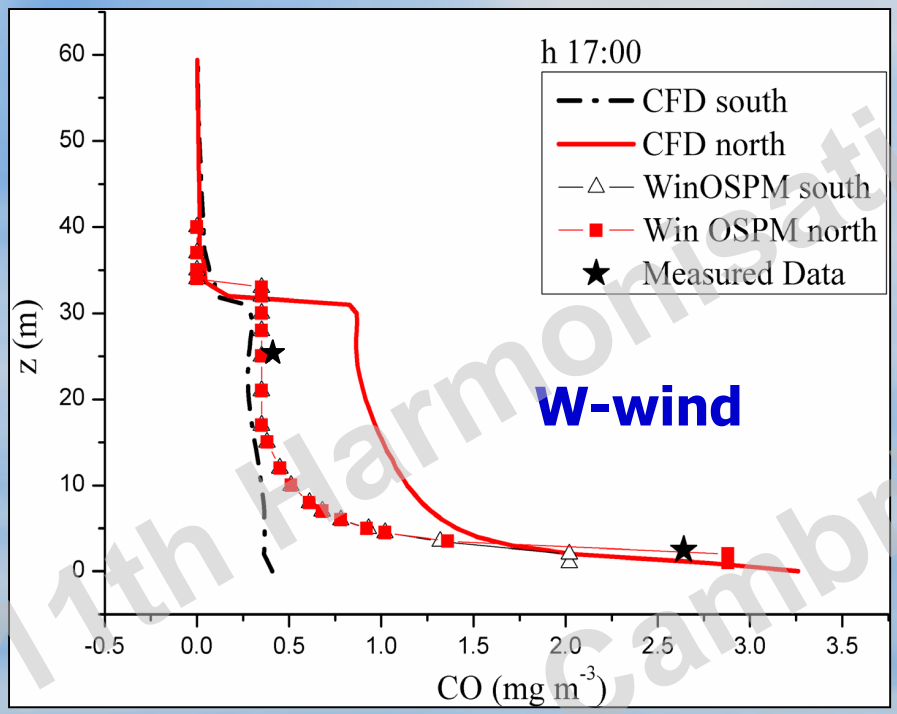
vertical CO profiles

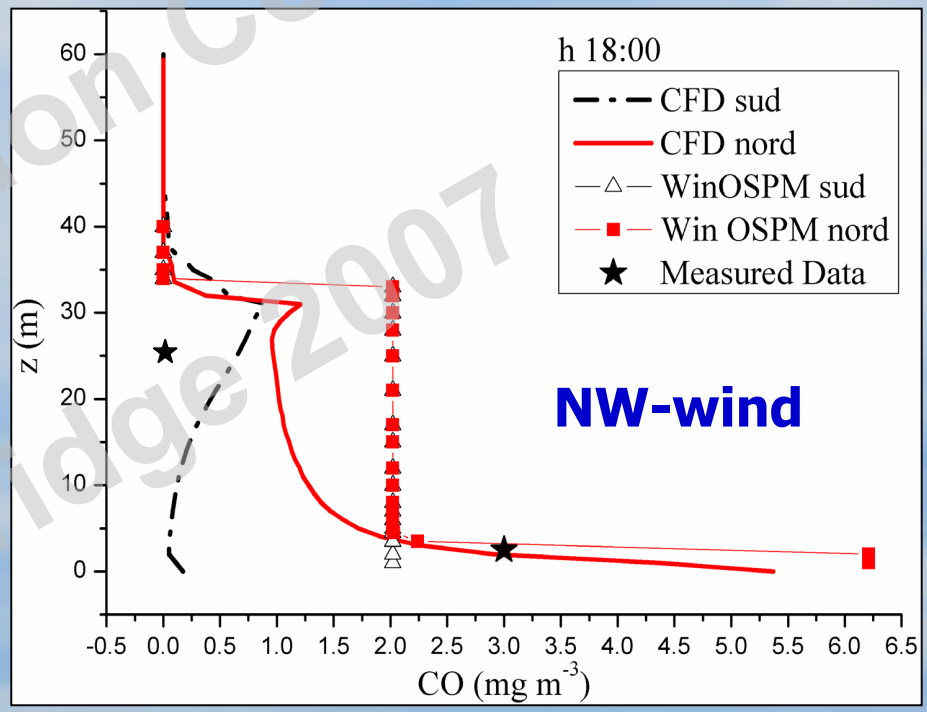




WinOSPM and FLUENT:

vertical CO profiles





Conclusions

- The two models predicted similar CO magnitudes, despite certain marked discrepancies
- Steep concentration gradients at street level and near the top of the buildings
- FLUENT captures wind vortex and pollutant recirculation effects, producing different profiles on either side of the street
- WinOSPM predicts similar vertical profiles on both sides of the canyon above street level and an exponential reduction of concentrations with height for parallel winds only
- **Further work:** CFD simulations for more wind regimes and deed street canyon configurations
- Development of an improved empirical parameterisation for deep street canyons in WinOSPM

Contacts

- Dr Fabio Murena (CFD simulations)
  murena@unina.it

- Dr Sotiris Vardoulakis (WinOSPM simulations)
  Sotiris.vardoulakis@lshtm.ac.uk

Thank you!