CONCORDIA UNIVERSITY – LOYOLA CAMPUS

A thermal comfort modelling framework for urban neighbourhoods: tempo-spatial coupling of building energy and CFD models

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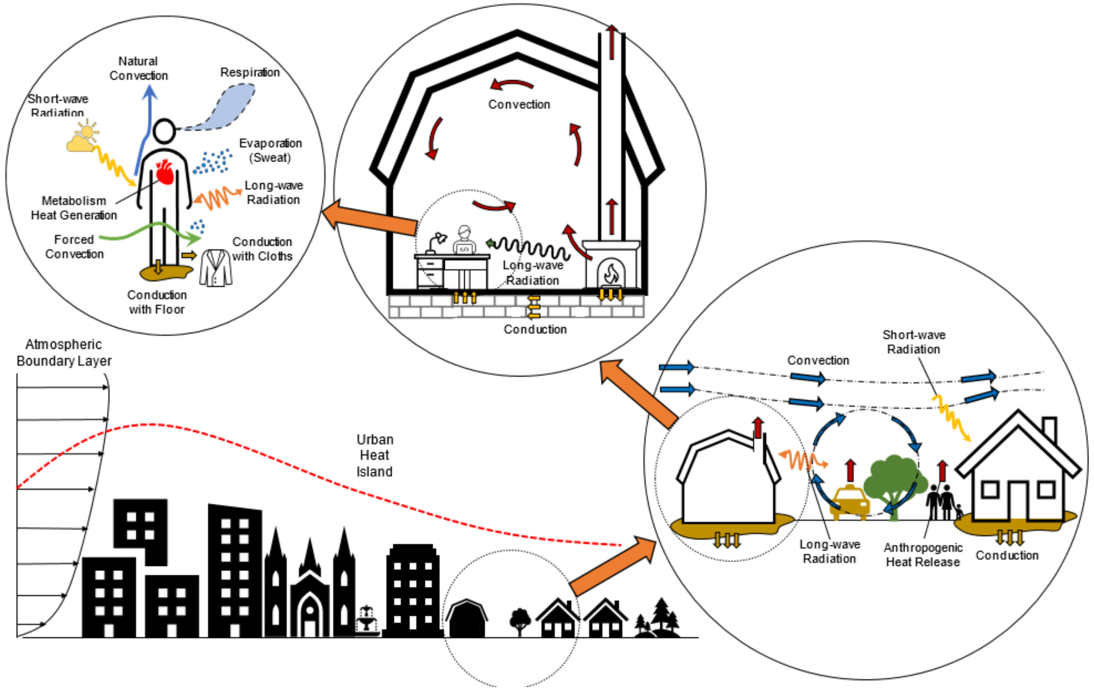
Outline

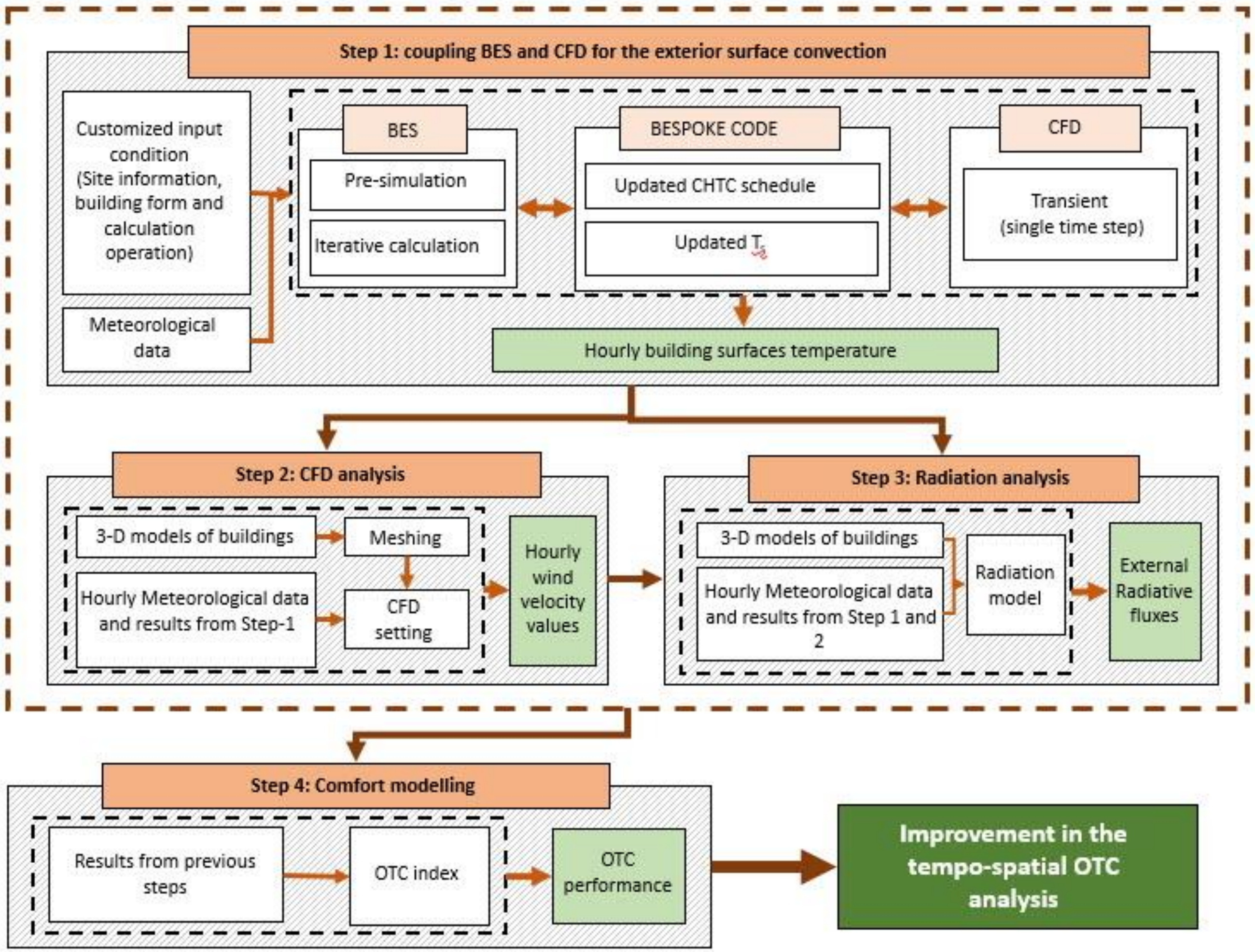
- Statement of the problem
- Proposed framework
- Case study
- Simulation results
- Conclusion

Statement of the Problem

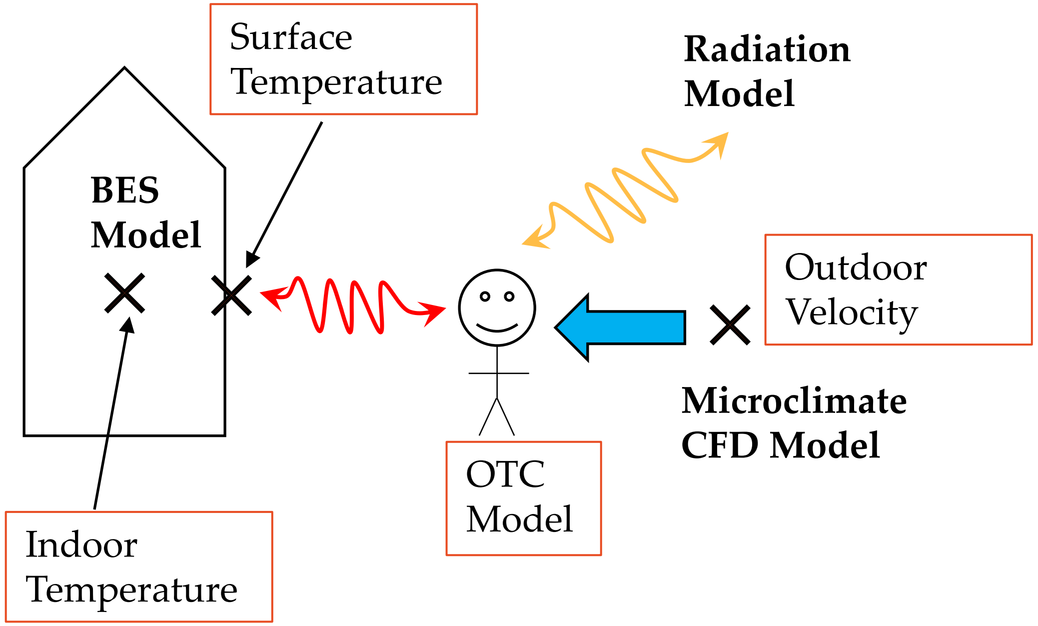
- Most thermal comfort studies focus on one of the radiative or convective models.
- BES tools ignore the neighbourhood effect
- CFD tools ignore the effect of a building's dynamic response
- As a potential solution coupling BES and CFD tools



Proposed Framework

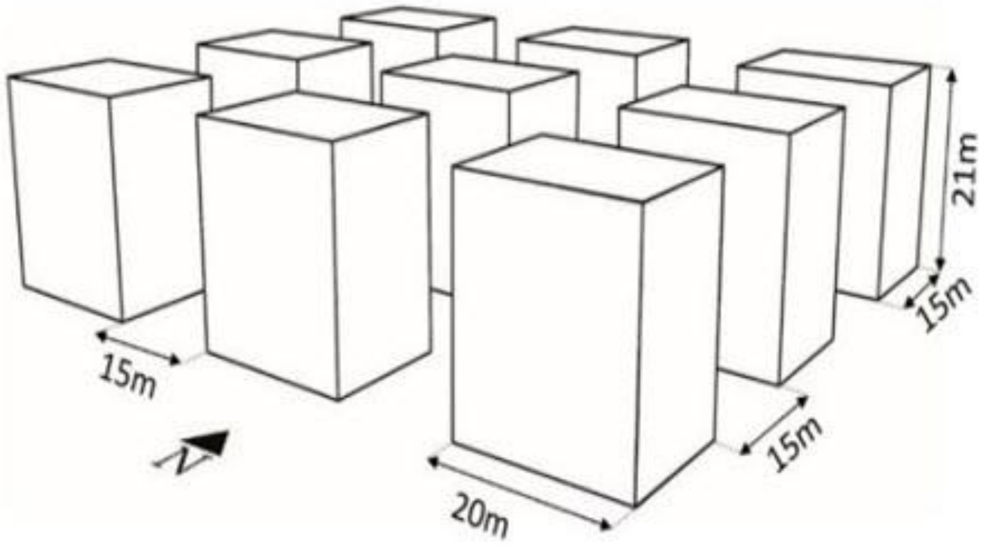


Employed in Grasshopper platform fed by outputs of ANSYS Fluent and EnergyPlus



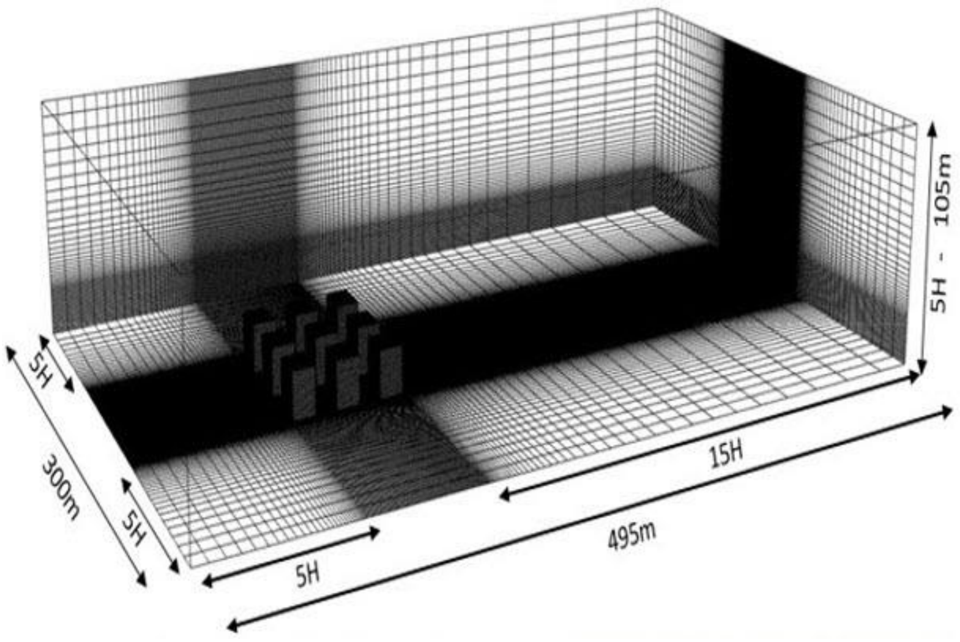
Case Study

- Nine building with seven floor: 63 thermal zone
- 8:00-19:00 on May 22nd of Tehran
- The main factor for selecting Tehran: the harsh solar condition with almost a high wind velocity pattern
- Energy analysis: Honeybee Grasshopper plugin that uses EnergyPlus as the BES engine



Microclimate CFD Simulation

- 3D steady Reynolds-Averaged Naviere Stokes (RANS) CFD simulations
- The 0.75m hexahedral grid in buildings and streets surfaces
- A grid sensitivity study: 3% deviation between the finer and basic mesh
- A user-defined function file for the surface temperature of buildings
- Turbulent scheme: realizable k- ε
- 20 wind scenarios to understand more probable wind directions and magnitudes



Calculation of Comfort Model

OTC modeling:

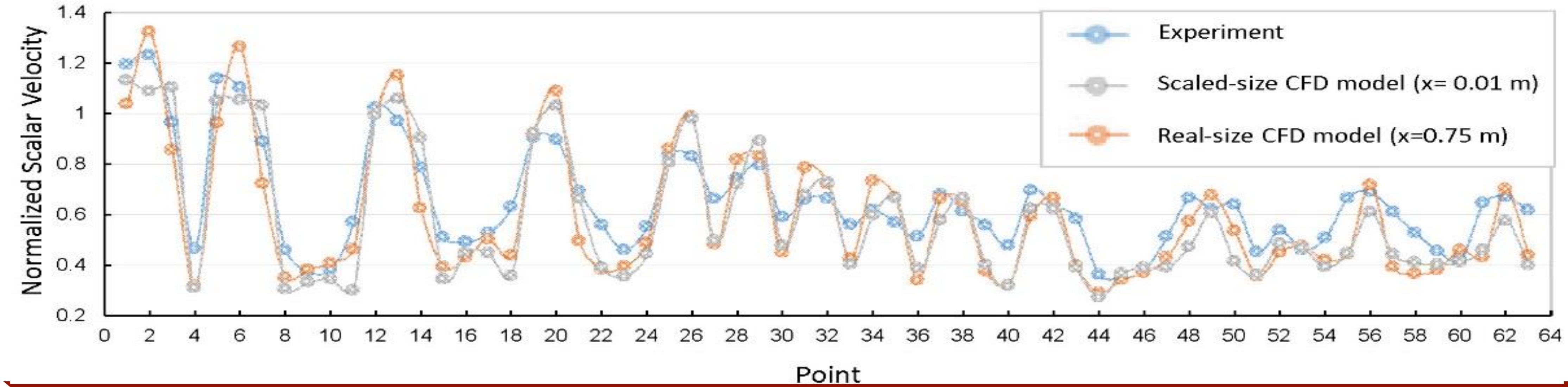
- PET is used as the default OTC index for determining the acceptable comfort range.
- PET consider the effects of air temperature, relative, humidity wind speed and MRT.

To standardize the impact of applying this framework on the OTC results:

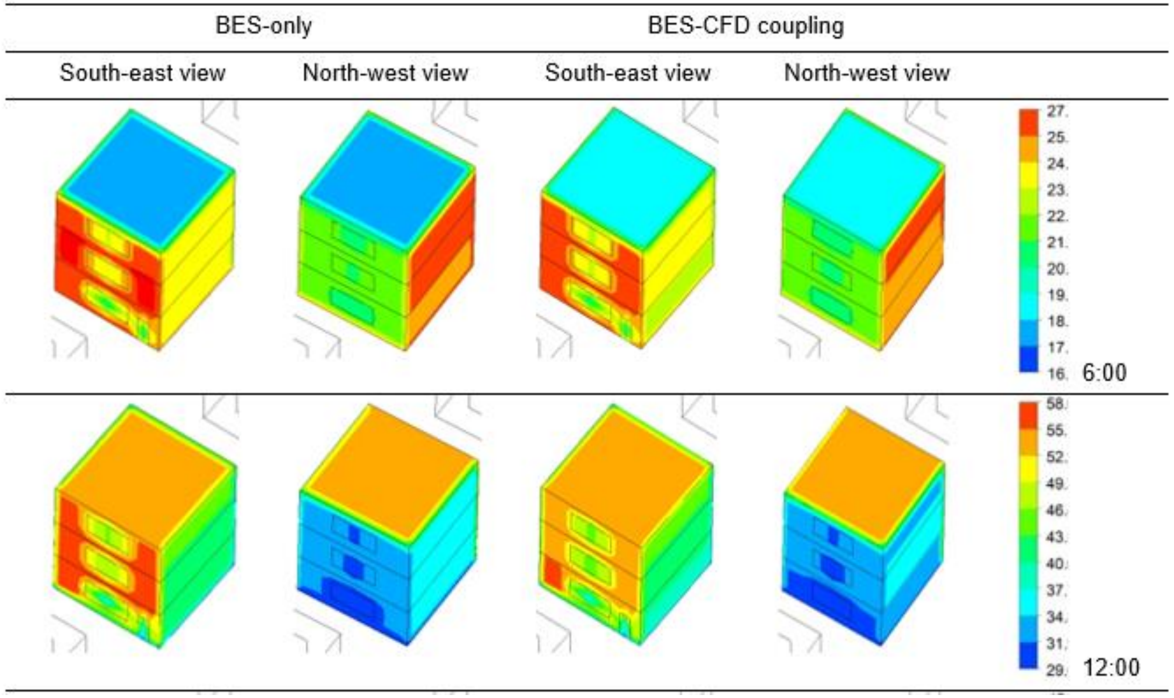
- $SI_h = \left|\frac{\mathrm{OTC}_2 - \mathrm{OTC}_1}{\mathrm{OTC}_1}\right| \times 100$
- SI_h is standardized impact at a specific time
- h is the hour of simulation

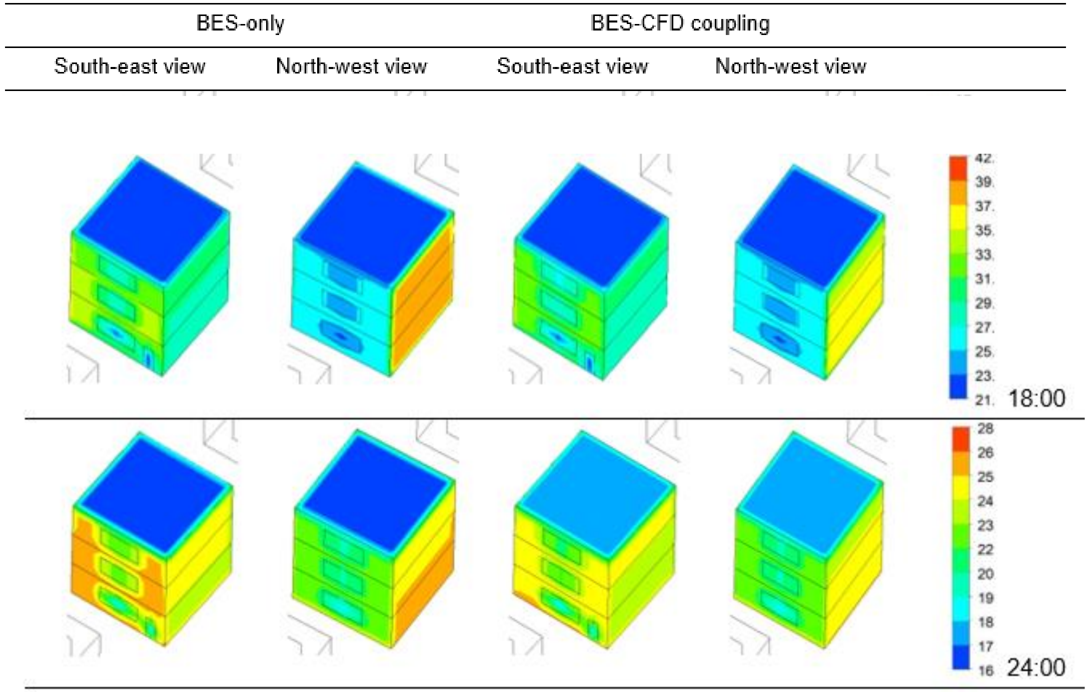
CFD Validation Results

- Comparison of measured (AIJ-Case C) and simulated wind speeds at 0.02m and 1.5m above ground for scaled-size and real-size models, respectively.
- Average deviations: 17.2% and 17.7% between the scaled- and real-size model simulations with the experimental results, respectively.



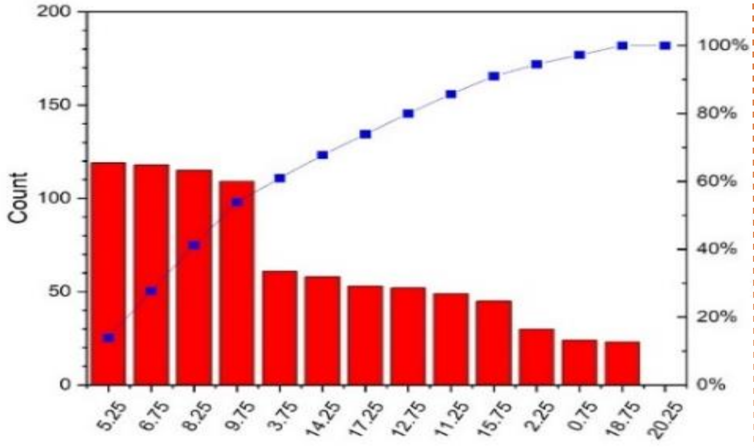
CFD BES Coupling Features



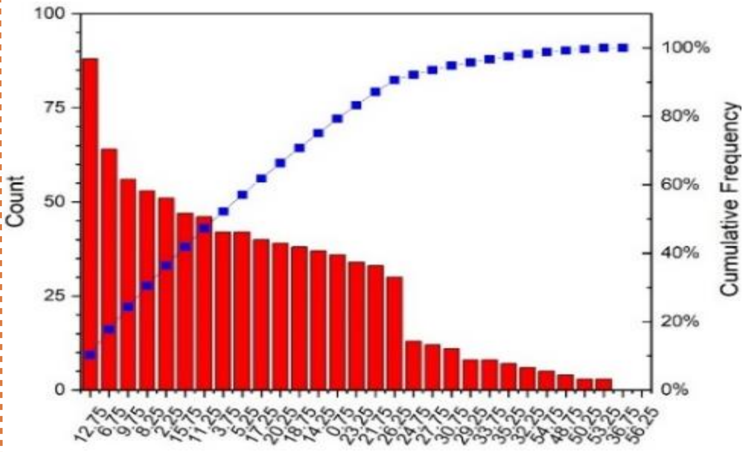


SI Values for the OTC Results

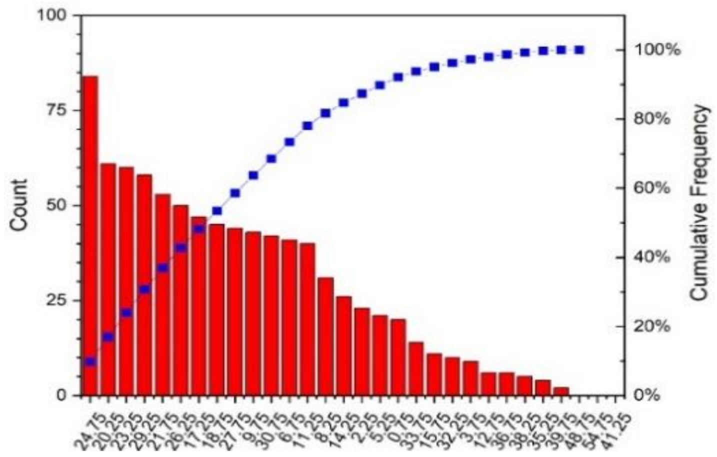
- wind velocity of 0.8 m/s at 8:00
- about 35% of points experience 5-7% changes in the PET values (SI of 5-7%)



- wind velocity of 8.0 m/s at 13:00
- about 55% of points experience more than 20% changes

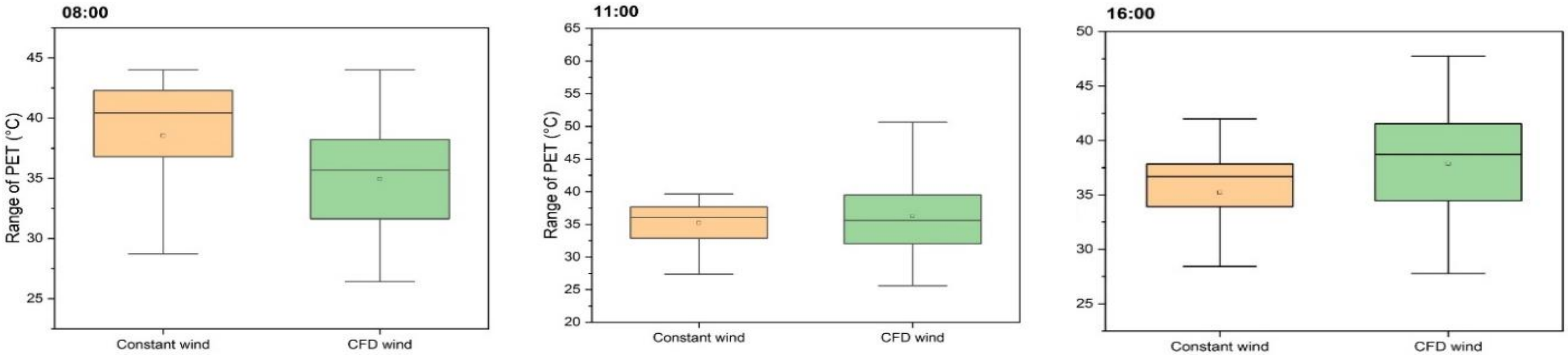


- wind velocity 13.5 m/s at 12:00
- 24% of points experience 20-24% changes

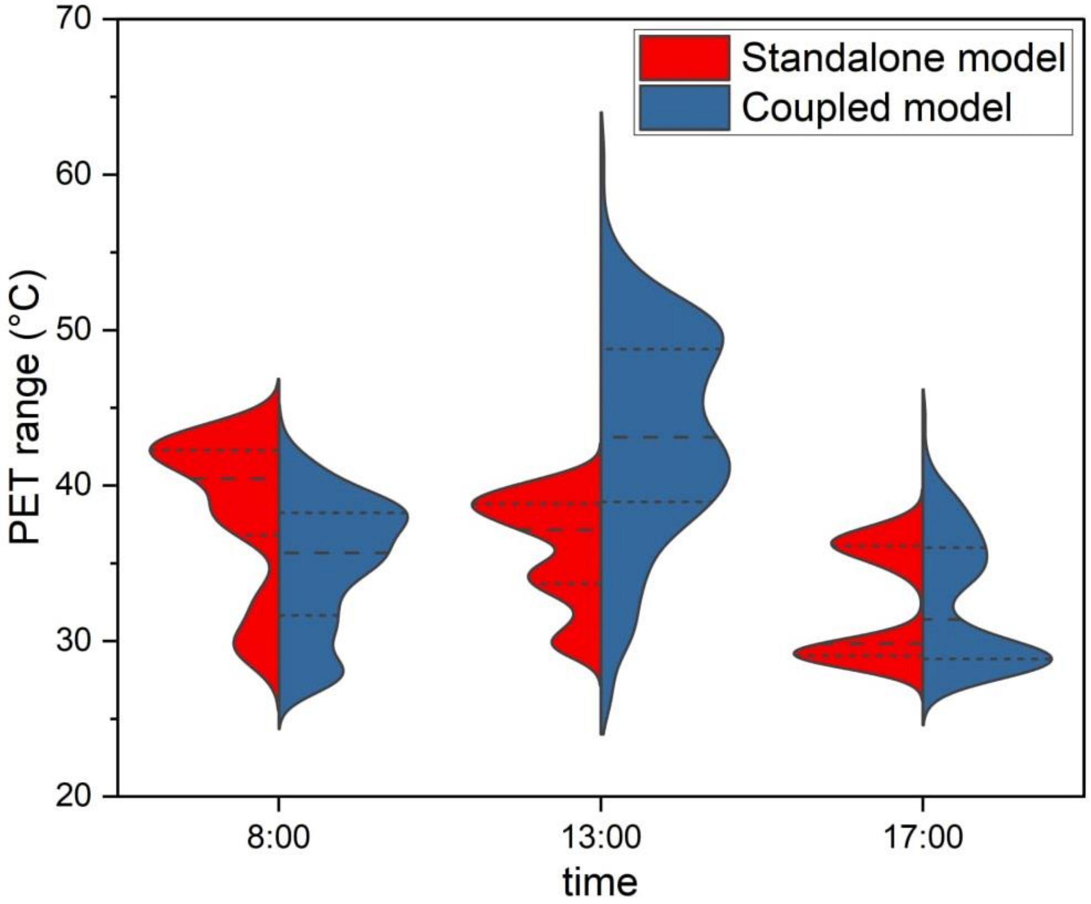


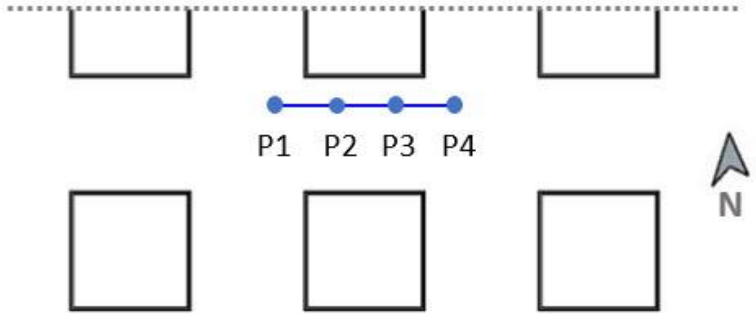
PET Results Comparison

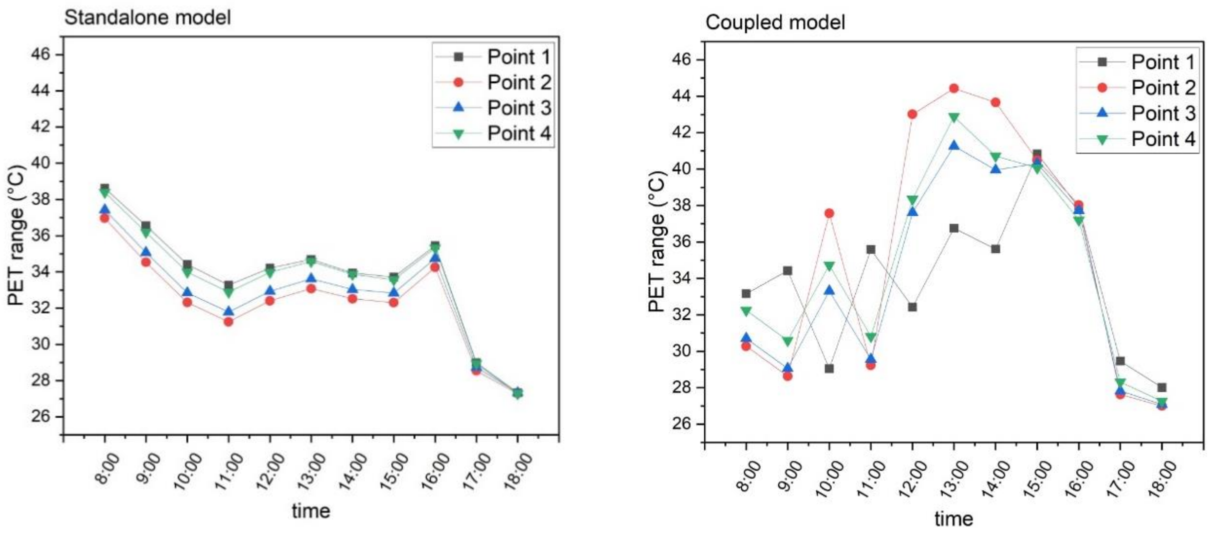
- Comparing the length of quantiles shows that OTC results with CFD-driven values are distributed in a wider range
- Each point experiences a wider range of PET when CFD-based results are incorporated while, by using constant wind values, this wide range of PET values is not seen.



PET Value Distribution







Conclusion

- The OTC simulation at neighbourhood scales is improved with this framework without increasing the computation cost.

- Results show that each point experiences a wider range of PET values when CFD-based results are incorporated.

- In proposed methodology, the most changes of the PET values happened at the building’s edges and in areas close to building surfaces.

Thank you!

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