West

Sydney Metro West

Hunter Street West Over Station Development

Addendum to Pedestrian Wind Assessment

April 2023

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Executive Summary

This report serves as an addendum to Pedestrian Wind Assessment at Appendix N of the Concept SSDA EIS, which covers wind comfort and safety impacts at ground level surrounding the proposed development.

This report specifically details the assessment of potential wind impacts at podium levels, which were unable to be assessed using wind tunnel testing methods in the previous Pedestrian Wind Assessment report.

The upper (level 53) podium has not been included in this assessment, as it does not influence the building envelope. Any wind impacts on this level can be assessed at a future design stage.

Wind impacts on pedestrians at podium levels were conducted using Computational Fluid Dynamics (CFD) simulations combined with statistical analysis of nearby meteorological observations.

The assessment was carried out against the City of Sydney DCP criteria and related to the intended use of the podium areas.

To accurately capture local flow behaviour, the effects of nearby buildings were modelled within a sufficient radius and to sufficient accuracy, as outlined in the Australasian Wind Engineering Society Quality Assurance Manual (2019). The local wind environment was modelled using twenty years of meteorological data and scaled according to AS/NZ 1170:2021 methods.

Details of the assessment criteria used, and applicable methodology, are provided in the previous Pedestrian Wind Assessment at Appendix N of the SSDA EIS.

The results of the study are summarised as follows:

- There are no DCP Wind Safety Standard exceedances in any podium areas.
- Wind conditions on the bottom podium satisfy the Wind Comfort Standard for Sitting, which is acceptable for any intended use of these areas.
- Wind conditions on the upper podium are generally acceptable for standing. Areas towards the podium edges exceed this criterion, however these exceedances are likely to be resolved by balustrades of a suitable height. Such mitigation measures should be tested at a future design stage.

1 Methodology

The assessment criterion and methodology (where applicable) are provided in detail in the Pedestrian Wind Assessment at Appendix N of the SSDA EIS. For this addendum, methodology specific to the Computational Fluid Dynamics (CFD) simulations is provided.

1.1 Computational Model

Surrounding physical features which influence the near field flow, such as significant buildings, structures, or topography, are essential to accurate wind modelling. The development, surrounding buildings and topography within 500 m radius were modelled to sufficient accuracy, following the Australasian Wind Engineering Society Quality Assurance Manual (2019). Images of the simplified model are provided below in Figure 1-1 and Figure 1-2.

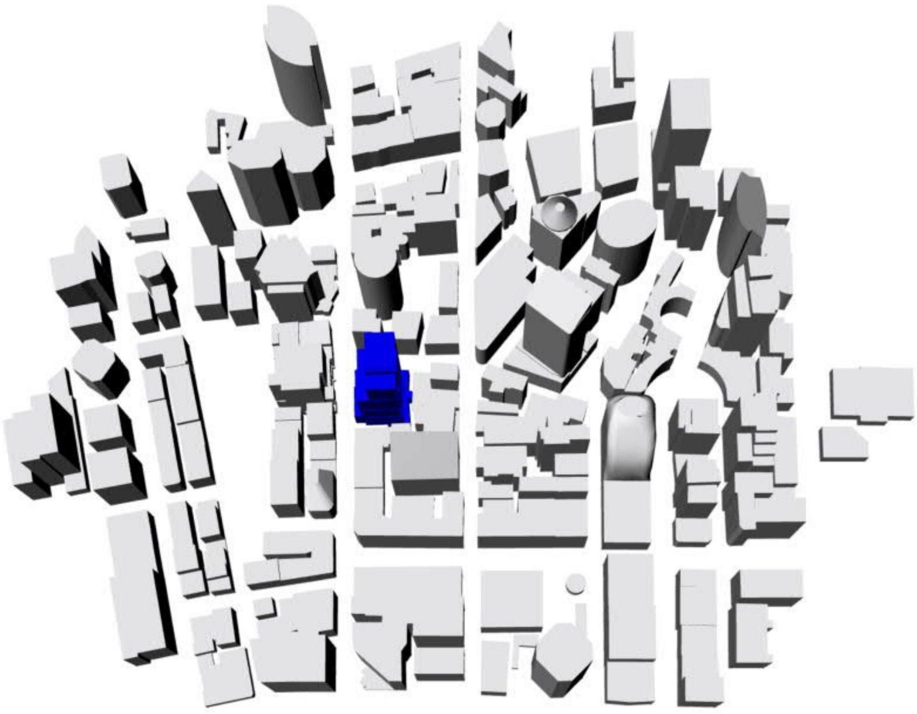


Figure 1-1 Model geometry, showing extents and detail of the surrounding buildings.

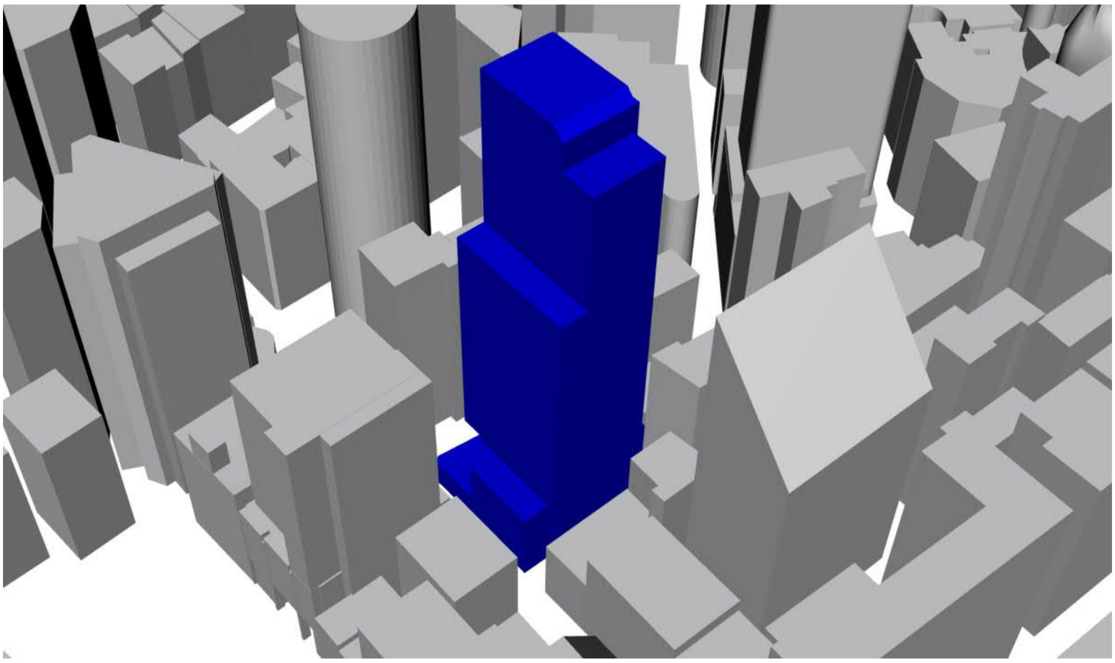


Figure 1-2 Model geometry, showing detail of Hunter St West site.

1.2 Statistical analysis

The methods used to assess CFD results against the DCP criteria are as follows:

- CFD was used to determine the mean wind speed ($\overline{U}$) and turbulent kinetic energy (k) at a height of 1.5 m for 16 wind directions relative to a reference wind speed of 10 m/s.
- For the DCP *comfort* criteria, gust-equivalent mean wind speeds, U_{GEM}, were calculated using:

$$U_{GEM} = \max\left(\overline{\mathrm{U}}, \frac{\overline{U} + 2.6\sqrt{k}}{1.85}\right)$$

  where 2.6 is the peak factor corresponding to a 3-second gust relative to a 10-minute mean. The gust factor of 1.85 has been used based on the research published by Lawson (2001).

- Comfort wind speeds were calculated using a Weibull statistical analysis (see Appendix B.2 of SSDA EIS Appendix N) of the gust-equivalent mean wind speed results, resulting in wind speeds with a 5% probability of exceedance from all directions.
- For the DCP *safety* criteria, gust wind speeds, $\widehat{U}$, were calculated using:

$$\widehat{U} = \overline{U} + 3.2\sqrt{k}$$

  where 3.2 is the peak factor corresponding to a 0.5-second gust relative to a 10-minute mean.

- Safety wind speeds were calculated using an extreme value statistical analysis (see Appendix B.3 of SSDA EIS Appendix N) of the hourly gust-equivalent mean wind speed results, resulting in wind speeds with a once-per-annum exceedance probability from all directions.

2 Results

2.1 Comfort

Wind comfort plots are displayed in Figure 2-1 and Figure 2-2. These results can be considered as a weighted average of wind events occurring from all directions, i.e. taking into consideration the relative probability of wind speeds from each direction.

For ease of reference, the results are displayed against the City of Sydney Wind Comfort Standards outlined in the Pedestrian Wind Assessment at Appendix N of the SSDA EIS. Unscaled gust-equivalent mean wind speeds for each wind direction are displayed in Appendix B, illustrating the wind conditions produced by each wind direction.

The wind comfort results, and mitigation measures which may be considered prior to Detailed SSDA, are summarised as follows:

Table 2-1 Summary of wind comfort assessment.

Area	Description of Results
Lower podium	Wind conditions across the podium areas are considered acceptable for sitting (e.g. outdoor dining), or can be considered acceptable for any outdoor activity.
Mid-level podium	Most areas are considered acceptable for standing, with areas towards the northern and southern ends of the podium considered acceptable for walking or uncomfortable. These areas are likely to fall within an acceptable category (standing or below) with the introduction of suitably high balustrades, which may be tested at a future design stage.

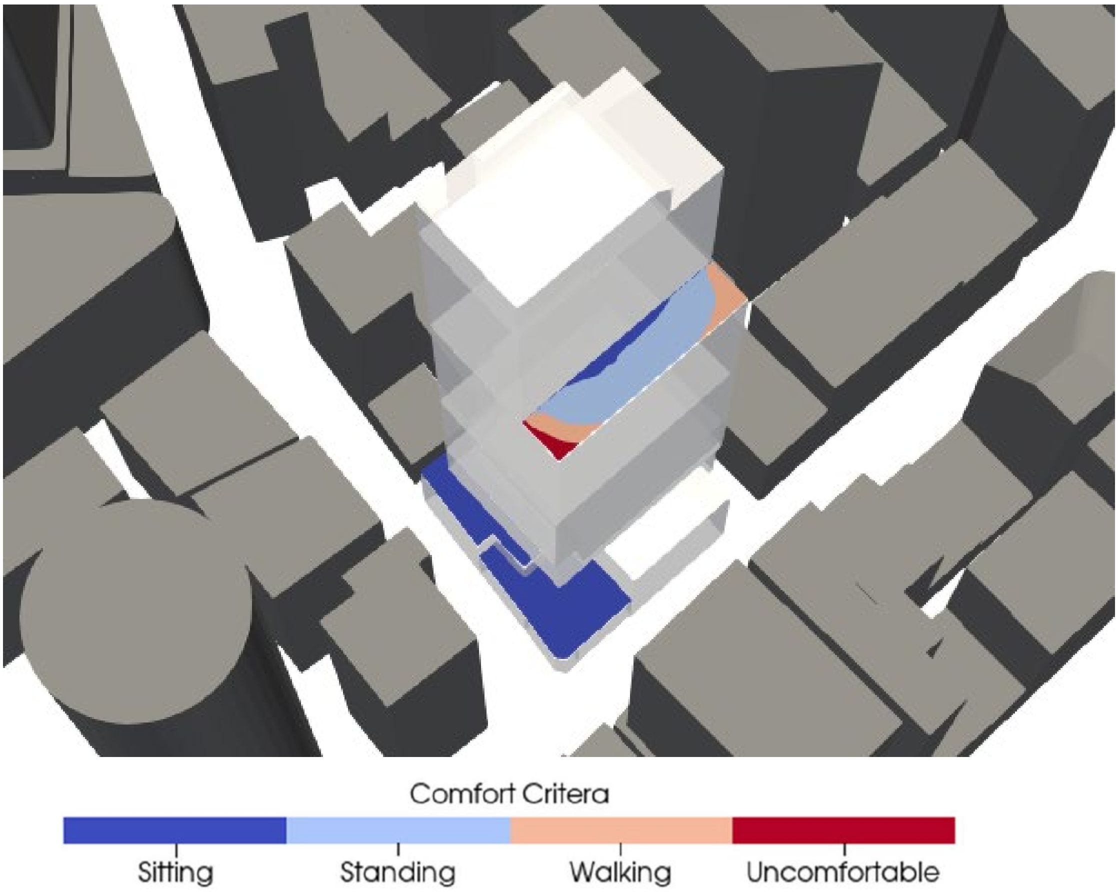


Figure 2-1 DCP Wind Comfort Standard results

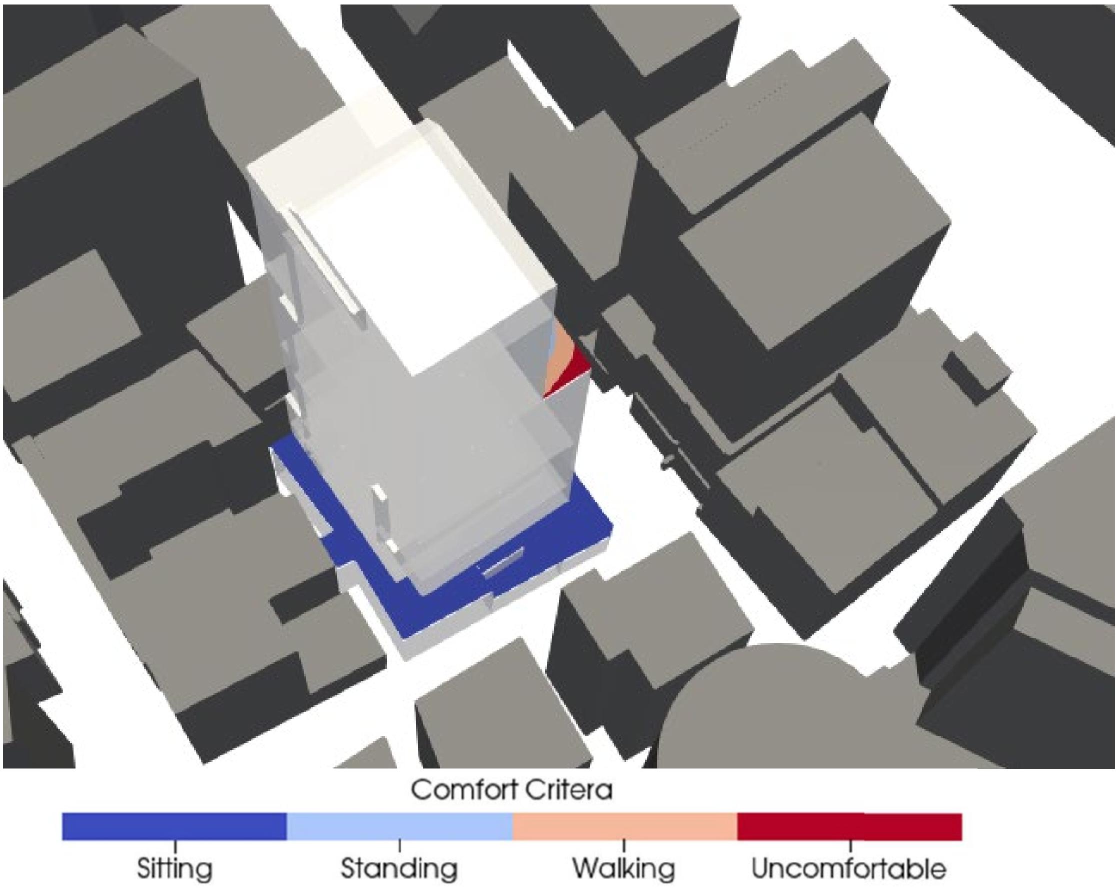


Figure 2-2 DCP Wind Comfort Standard results, alternative view

2.2 Safety

Wind comfort plots are displayed in Figure 2-3 and Figure 2-4. As with the comfort contours above, the results represent wind events from all directions. There are no exceedances of the DCP Wind Safety Standard in any of the podium areas assessed.

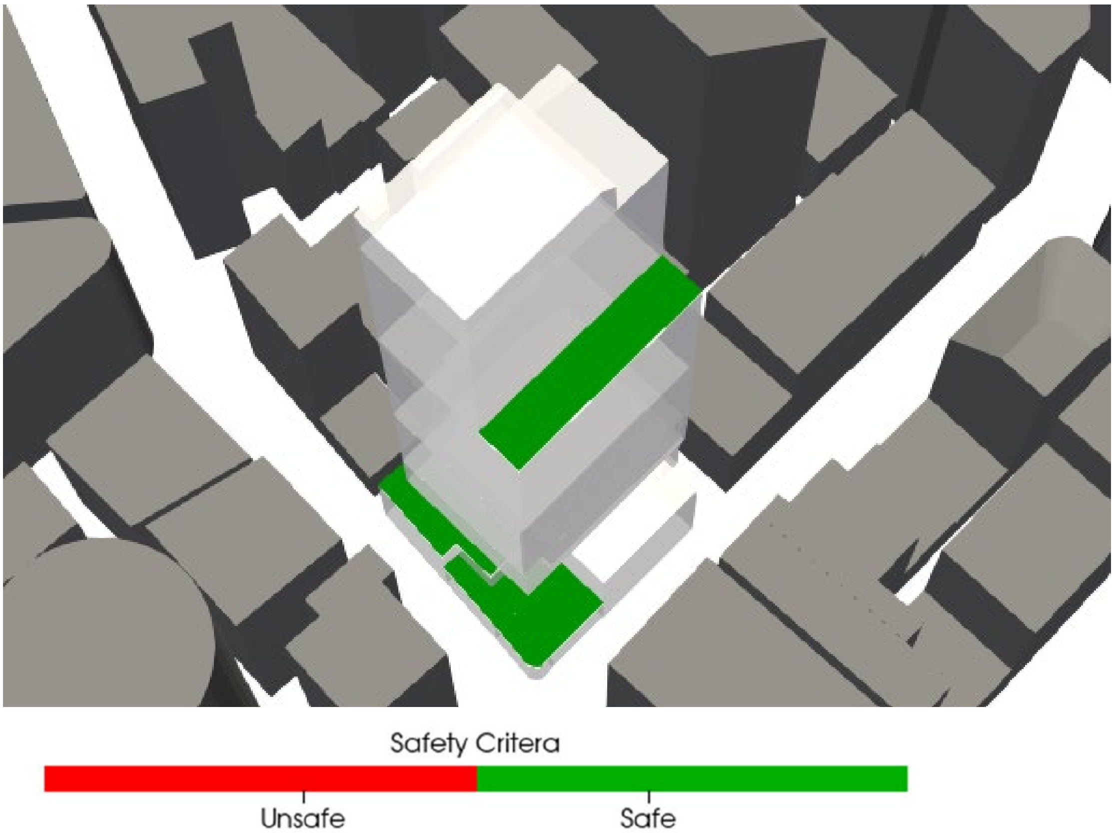


Figure 2-3 DCP Wind Safety Standard results

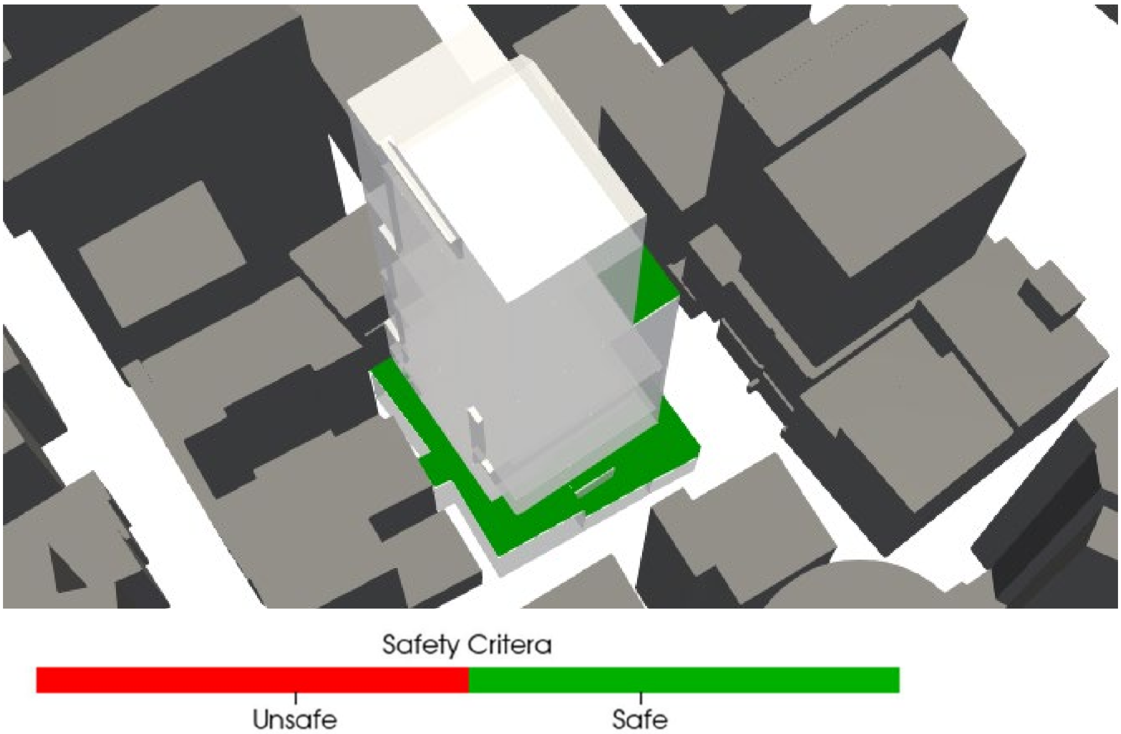


Figure 2-4 DCP Wind Safety Standard results, alternate view.

3 Conclusion

A CFD study of pedestrian-level winds has been conducted to assess comfort levels experienced by pedestrians at the podium of the Hunter Street West site.

The assessment has been provided to supplement previous results provided in the Pedestrian Wind Assessment in Appendix N of the SSDA EIS, which did not cover the podium areas.

The assessment was completed using a combination of CFD and statistical analysis of meteorological observations to calculate comfort and safety wind speeds at pedestrian height. Assessment was carried out against the City of Sydney DCP Wind Comfort Standards and Wind Safety Standard, considering the intended use of the podium areas.

Wind conditions at the bottom podium area are acceptable, satisfying the Wind Comfort Standard for Sitting.

On the mid-level podium, some areas are above acceptable conditions for sitting and standing. It is likely that these issues can be mitigated with the introduction of suitably high balustrades

There are no Wind Safety Standard exceedances for any podium areas considered in this study.

Appendix A Detailed CFD Methodology

A.1 Numerical Methods

The analysis uses a Computational Fluid Dynamics (CFD) model which predicts fluid flows by mathematically modelling the Reynolds Averaged Navier-Stokes equations; fundamental equations which describe fluid motion. OpenFOAM software was used; its reliability well validated by academic researchers and independent organisations.

CFD simplifies estimates of turbulence, models average flow conditions well and random flow conditions with less accuracy. The turbulence closure scheme used for the modelling in this report was the realisable k-ε model. This model has been extensively validated for urban flows and has been shown to have superior performance for highly separated flows when compared with the standard k-ε model.

A.2 Computational Domain and Meshing

A cylindrical computational domain was used for the analysis. The domain size was selected to allow at least 10h from the extents of significant geometry to the, where h is the height of the tallest building, following COST recommendations. An outflow length of 7h was used and mesh refinements were made down to a minimum 0.16 m edge length.

A.3 Approach Flow and Boundary Conditions

Accurate CFD simulations require appropriate modelling of conditions at the model boundaries. Of particular importance are the inlet velocity and turbulence conditions, which were modelled using the AS/NZS 1170.2:1989 boundary layer profiles for mean velocity and turbulent kinetic energy. The ground plane roughness was modelled to ensure the boundary layer profile remained constant (neutrally stable) throughout the approach and far-field.

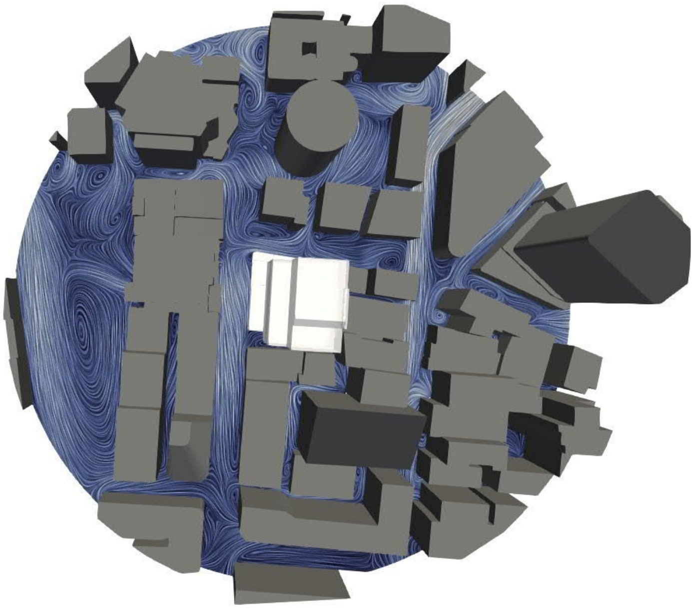
Additional boundary definitions were:

- the top boundary having a shear stress and vertical gradient in epsilon following the recommendations of Richards and Hoxey,
- outflow boundary with zero gradient in pressure,
- side boundaries based on a mixed inlet/outlet condition,
- bottom (ground) boundary as a no-slip wall with wall roughness function applied, and
- building surfaces as no-slip walls.

Wall functions were used to model the viscous sublayer flows near no-slip walls to accurately model wall friction effects. Changes in wind speed with direction were accounted for in postprocessing calculations using Weibull distribution parameters.

Appendix B Unscaled Gust-equivalent Mean Wind Speeds from Individual Wind Directions

N



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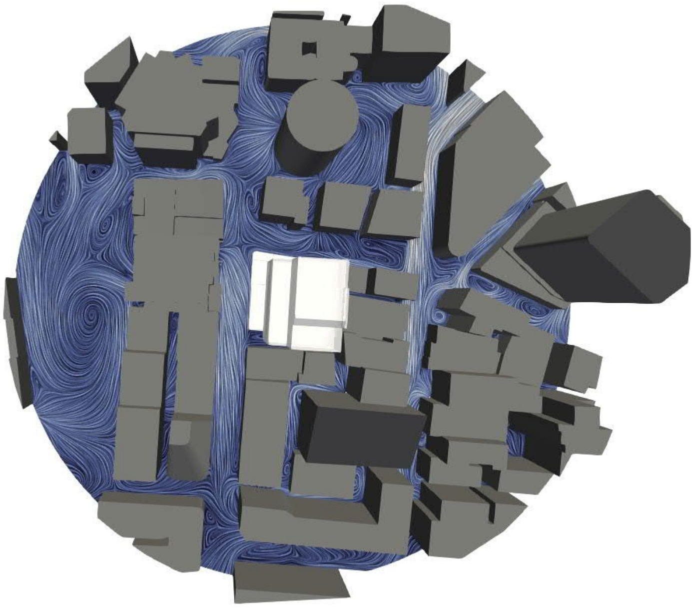

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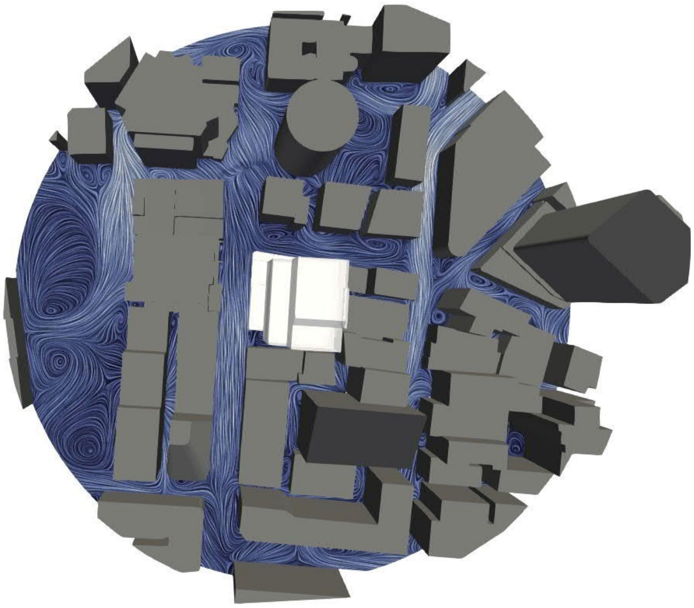

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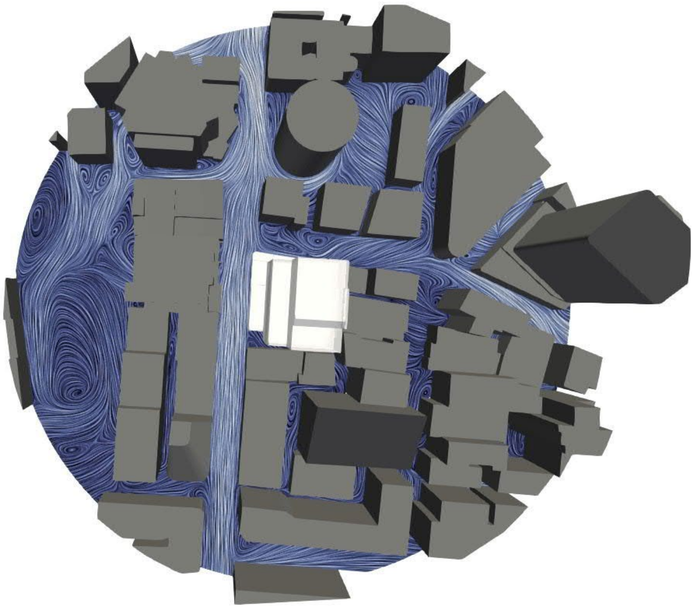

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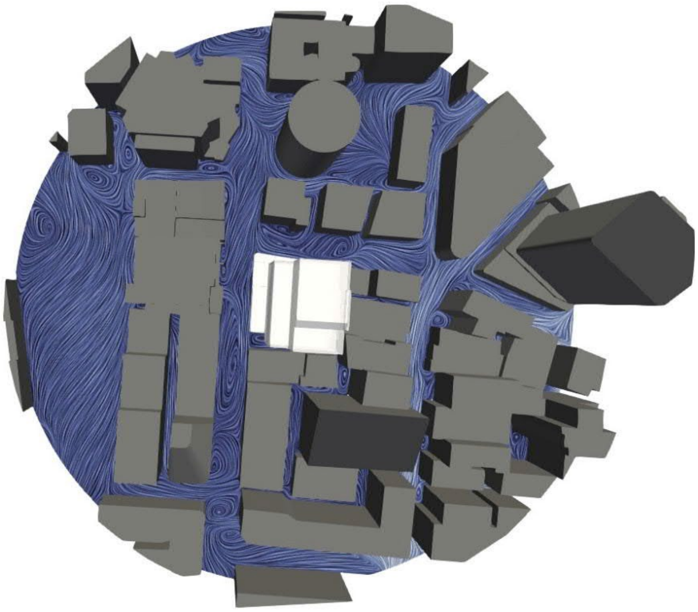

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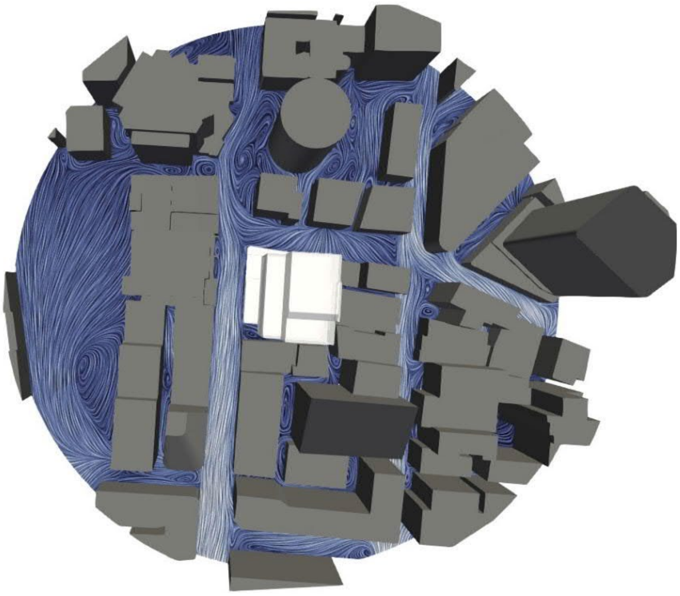

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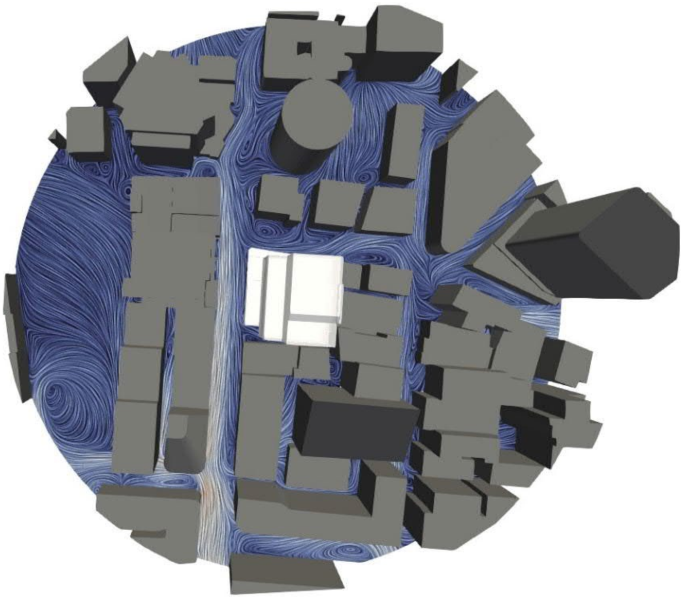

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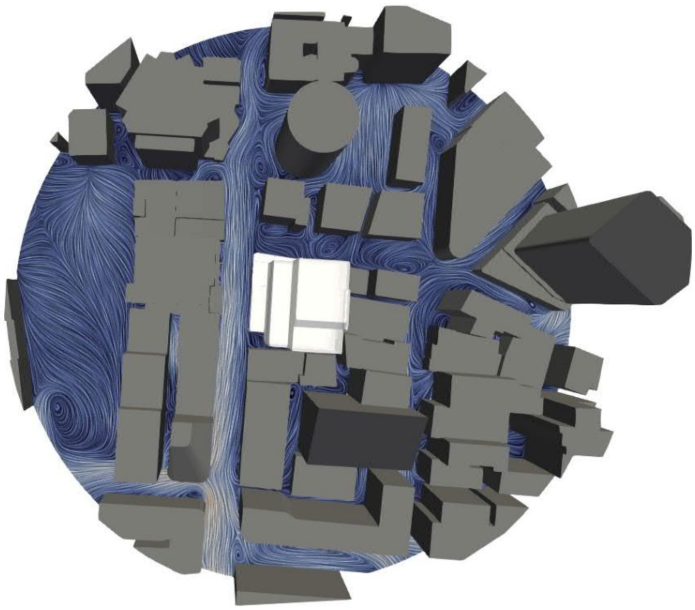

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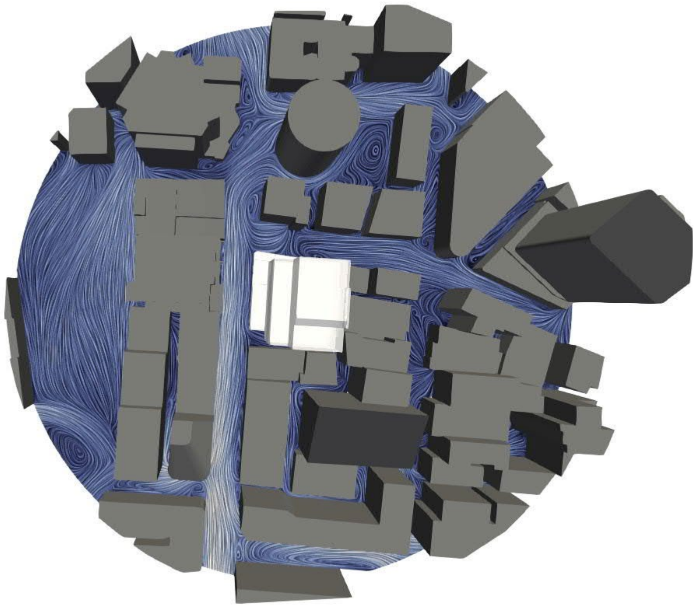

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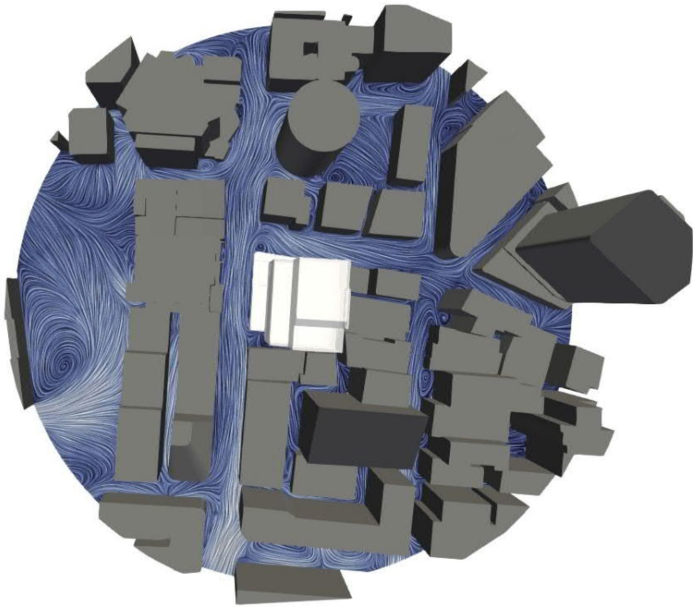

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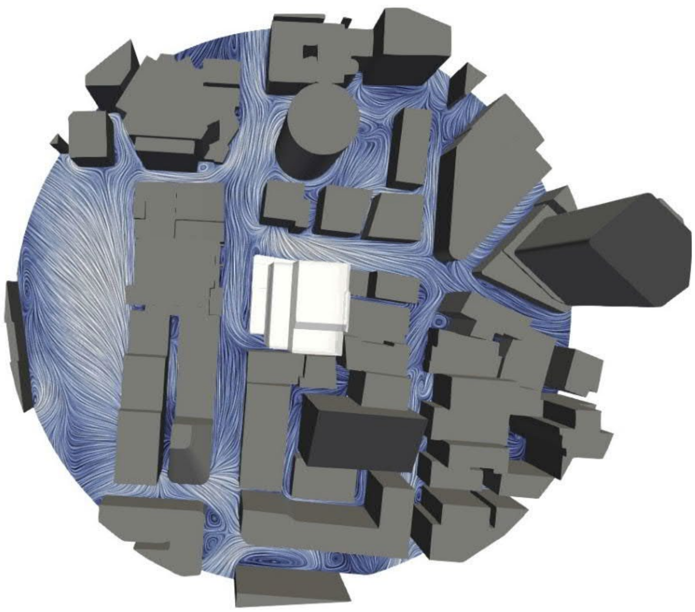

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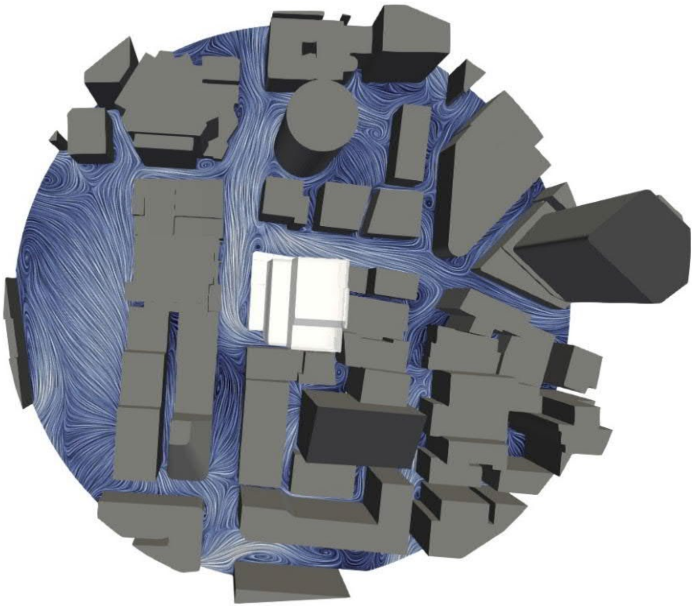

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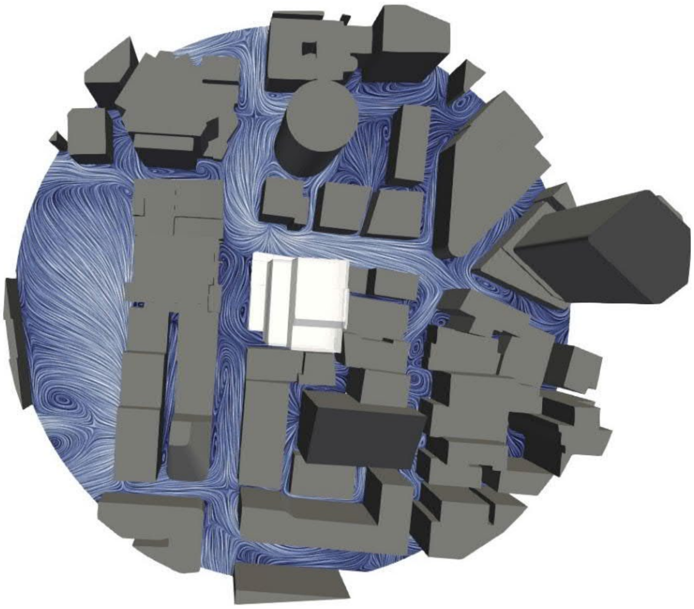

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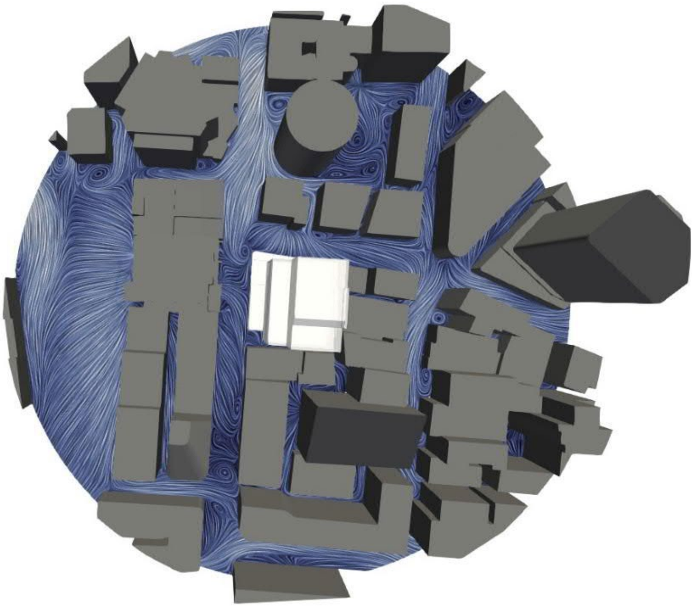

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