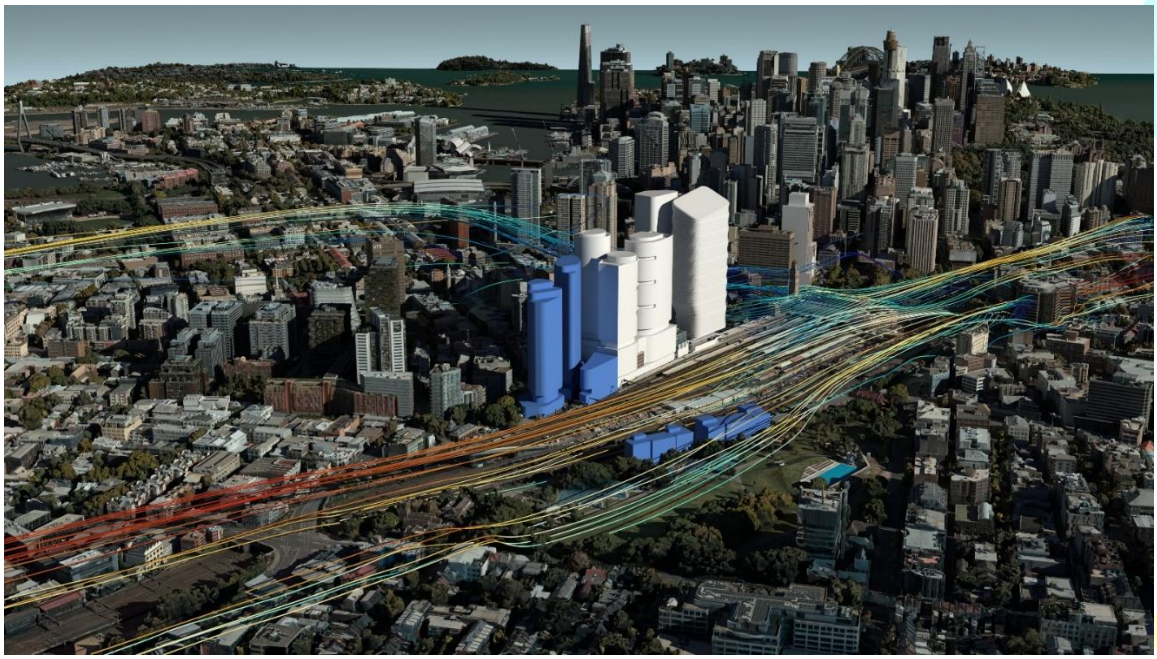
Central Precinct Finalisation

25 March 2025

298-25-L2T

Environmental wind study



LAMINAR2 TURBULENT PTY LTD

THERMO-FLUID DYNAMICS TECHNICAL CONSULTING SERVICES

Central Precinct Finalisation
Environmental wind study

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Confidential

REVISION HISTORY

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CONTENTS

SUMMARY

An environmental wind impact assessment has been performed for the finalisation of the rezoning proposal for Central Station Precinct which involves removal of the Over Station Deck (OSD) and a residential scheme for Prince Alfred sidings using computational fluid dynamics (CFD). A wind assessment as defined in the City of Sydney DCP (2012), Section 5.1.9. was performed for the existing condition and future proposed configurations.

The CFD wind assessment showed that all public open spaces satisfied the wind safety criterion except for a small area to the north of Western Gateway Block A (Atlassian Building) due to the introduction of the raised walkway as part of the Central Square redevelopment proposal.

In terms of pedestrian comfort, all areas are aligned with the recommended Central Precinct Design Guidelines except for northern half of Mortuary Square Gardens which exceed the desired localised sitting wind comfort criterion.

For the exceedance of the safety criteria to the north of Block A, further assessment and development of localised mitigation measures at Development Application (DA) stage is recommended. Similarly, a built-form and/or hard landscaping solution to the Regent Street Sidings aimed at reducing wind conditions in Mortuary Square Gardens should be developed.

It is recommended that the Central Precinct Design Guidelines be updated to remove references to the OSD specifically Section 8.3 Wind safety and comfort.

This assessment appends previous study by L2T on the RTS which was summarised in *Report 64-20-CFD-ENV-04.*

1. INTRODUCTION

L2T have been appointed by Architectus to perform an environmental wind impact assessment for the Central Station Precinct to support finalising the rezoning proposal put forth by Transport for New South Wales (TfNSW). This proposal responds to the NSW Government's decision to remove the over station development (OSD) which was present in previous wind studies issued by L2T. Instead, this wind assessment comprises only of the following sub-precincts:

- Regent Street Sidings
- Goulburn Street Car Park
- Prince Alfred Sidings.

The site is shown in Figure 1 which shows the extent of the OSD which has been removed from this latest assessment, and the sub-precincts listed above.

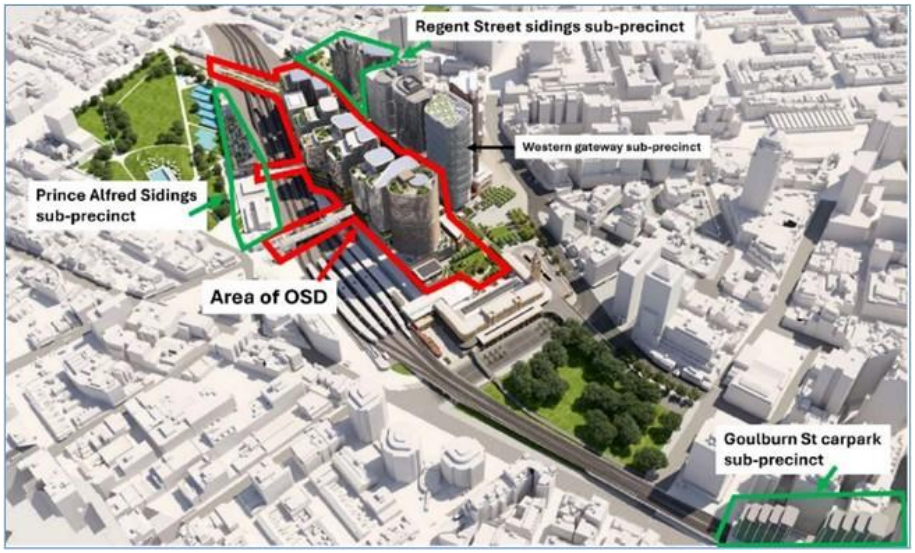

Figure 1: Satellite image showing the location and surrounding context of the site

The purpose of this wind study is to quantify the wind comfort for the remaining publicly-accessible open spaces, and to identify any adverse wind impacts due to the removal of the OSD. Furthermore the wind study should determine if the updated proposal is capable of meeting the guidance set out in the Central Precinct Design Guide and recommend if design guide changes are required to ensure appropriate wind conditions can be achieved at the DA stage or advise of other design measures to reduce wind impacts.

1.1 Regulatory context

The site is located within the administration of the Sydney Local Environment Plan which is supported through the Central Precinct Design Guide (2024). This document provides performance-based controls specific to development in Central Precinct, with Section 8.3 of this document covering wind safety and comfort, prescribing objectives and guidance.

1.2 Wind environment assessment

Wind environment assessments fall outside the scope of the Australian Standard for wind actions on structures, AS/NZS 1170.2:2021 (Standards Australia, 2021). Additionally, the complexity of urban winds means there are no reliable analytical methods which can accurately assess the pedestrian wind environment.

The method used in this study is the result of extensive experience and validation benchmarked against guidance documents from around the world and used on 100+ projects around Australia and Internationally. L2T were involved in the development of the Australian Wind Engineering Society's Computational Wind Engineering Quality Assurance Manual (QAM) (AWES, 2024) and the methodology used in this analysis meets or exceeds these requirements.

2. METHODOLOGY

The methodology outlined in L2T's report 64-20-CFD-ENV-04 is applicable to the analysis performed in this report. Methodology specific to this assessment are described below.

2.1 Geometry and mesh

The three-dimensional CAD model used in the previous study (RTS Masing Op3.10, CFD Option 6) was modified to align with the removal of the OSD. All existing buildings and buildings under construction within an approx. 1000m radius were modelled based on 3D buildings information and was checked to ensure any recent buildings were up to date. The terrain was explicitly modelled around the study area using a digital elevation model (DEM). The CAD model is shown in Figure 2. The detail of the model increases around the proposed buildings down to approx. 0.15m on the buildings of interest.

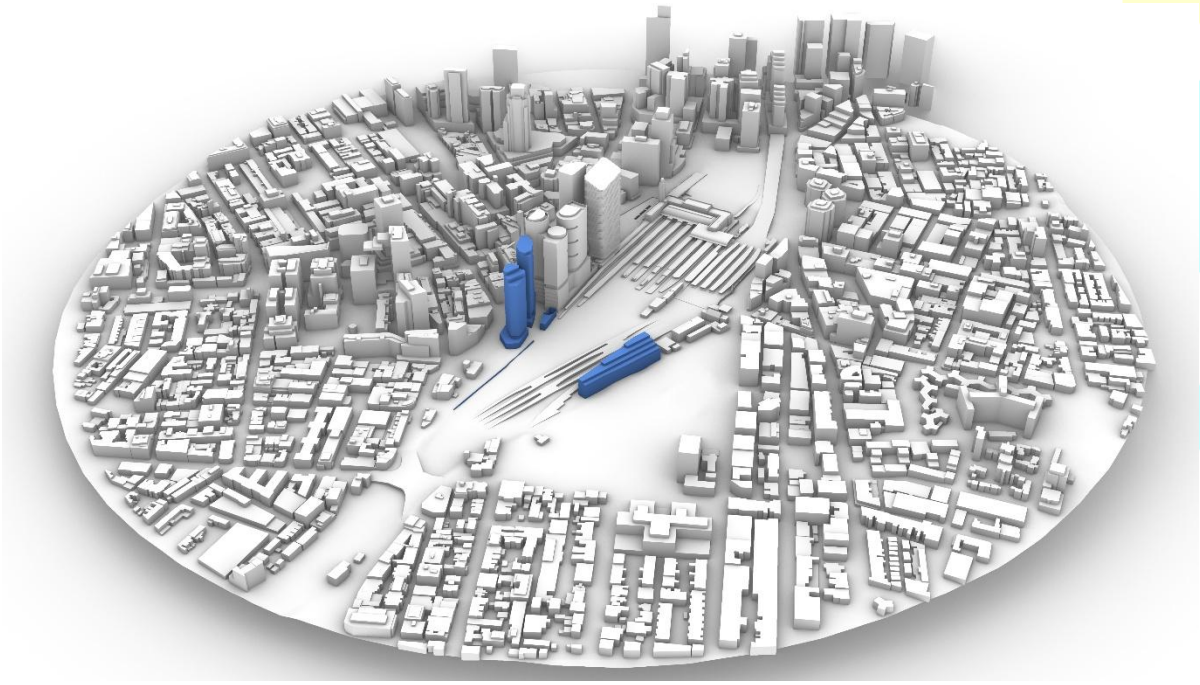

Figure 2: 3D CAD model of the terrain, context and proposed buildings

Three scenarios were assessed, which are shown in Figure 3 to Figure 7, were:

- Existing: existing site including the Western Gateway in the context of existing buildings
- Option 1: Proposed development including the commercial scheme on Prince Alfred Sidings
- Option 2: Proposed development including the residential scheme on Prince Alfred Sidings, the proposed Central Square development, addition of built form on substation, and addition of an acoustic barrier parallel to the rail lines

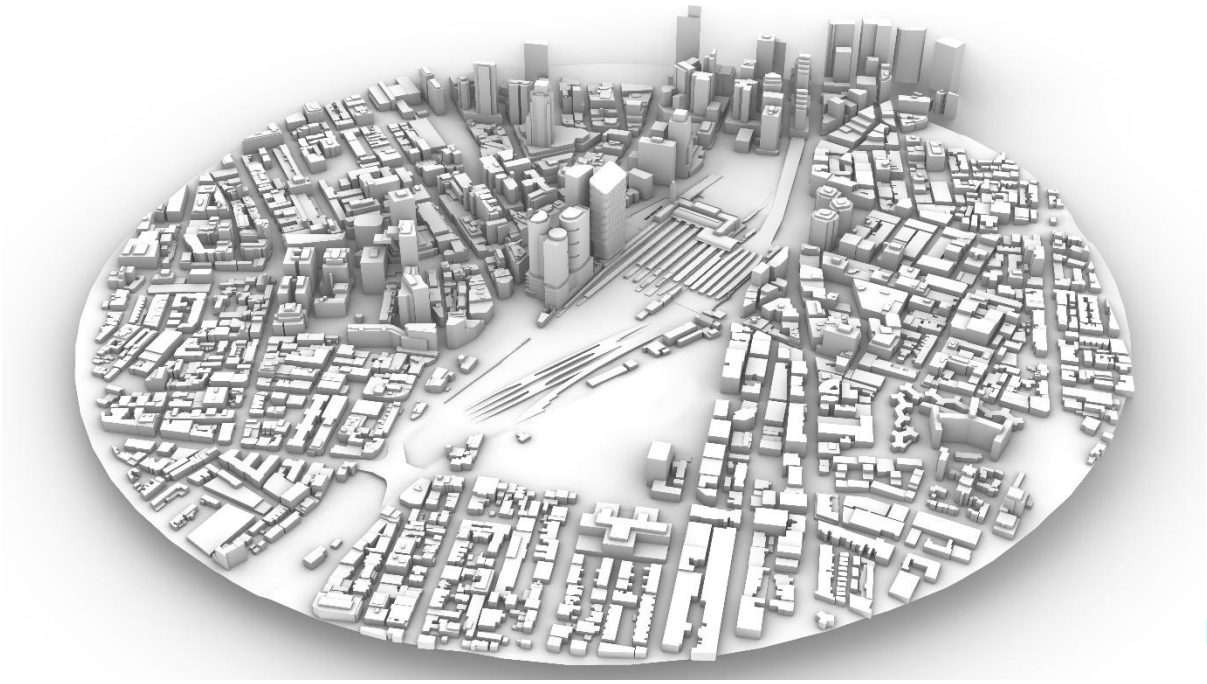

Figure 3: 3D CAD model of the terrain, context of the existing scenario

Figure 4: View from the south east of Option 1, showing the proposed Alfred Street Sidings commercial development

Figure 5: View from the south west for Option 2 showing the Western Gateway and the proposed Regent Street Sidings

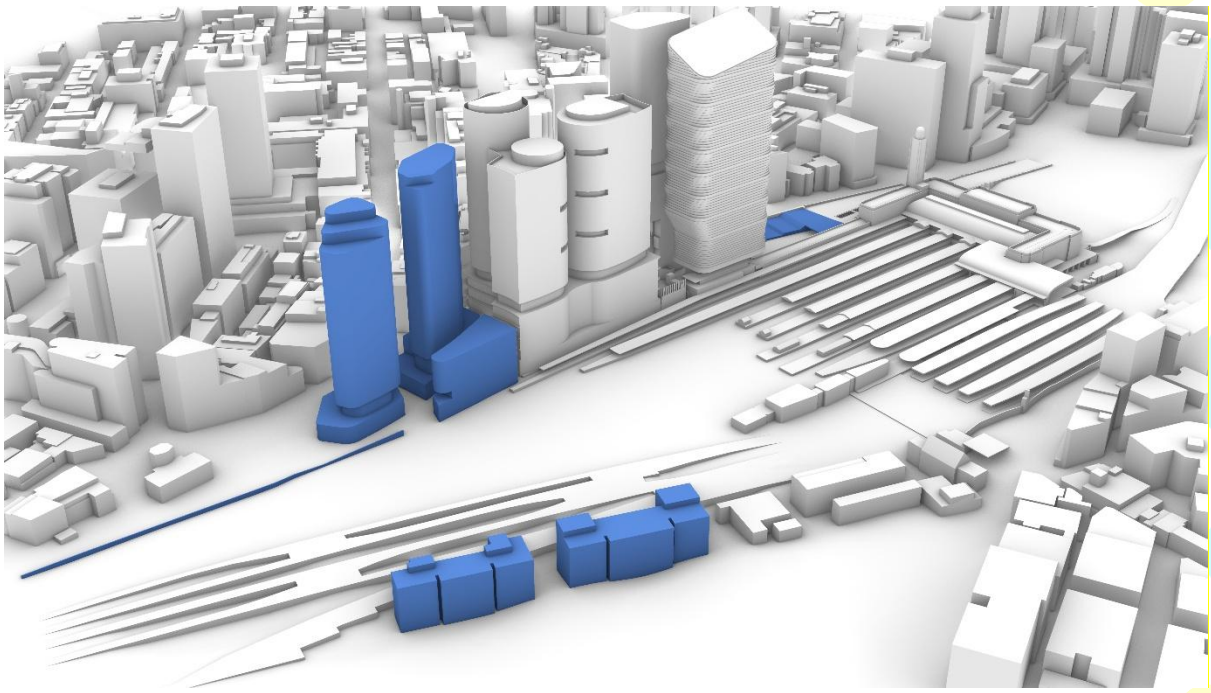

Figure 6: View from the south east of Option 2, showing the proposed Alfred Street Sidings residential development

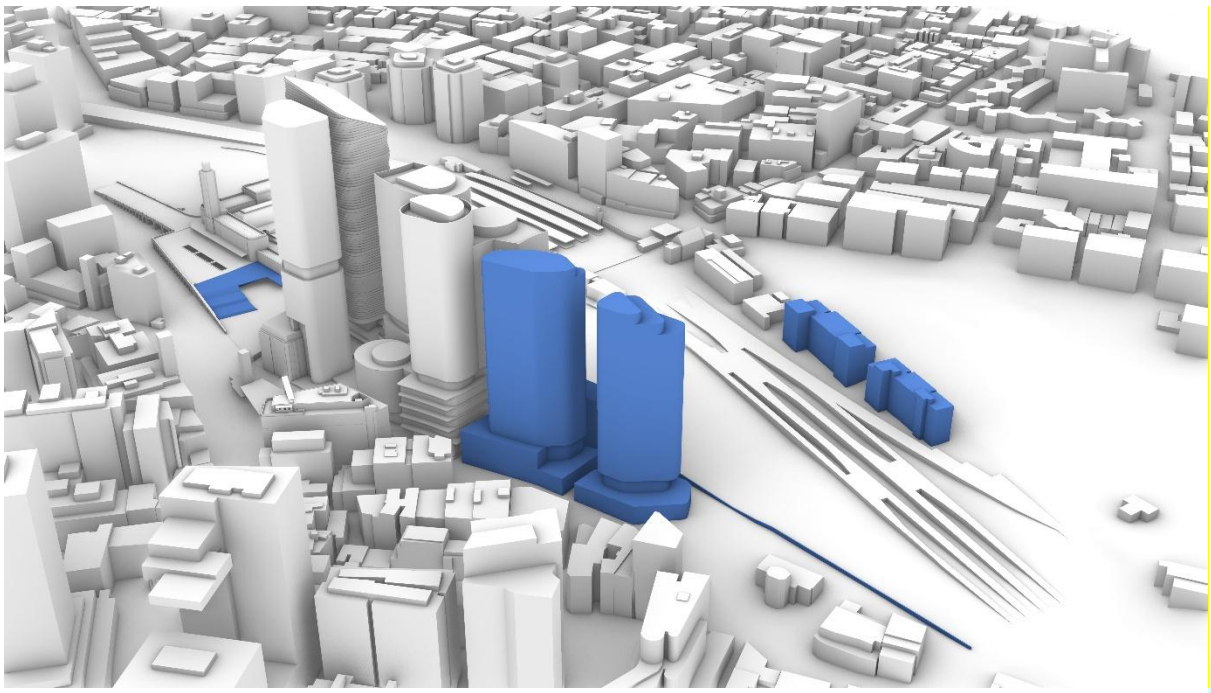

Figure 7: View from the south west for Option 2 showing the Western Gateway and the proposed Regent Street Sidings

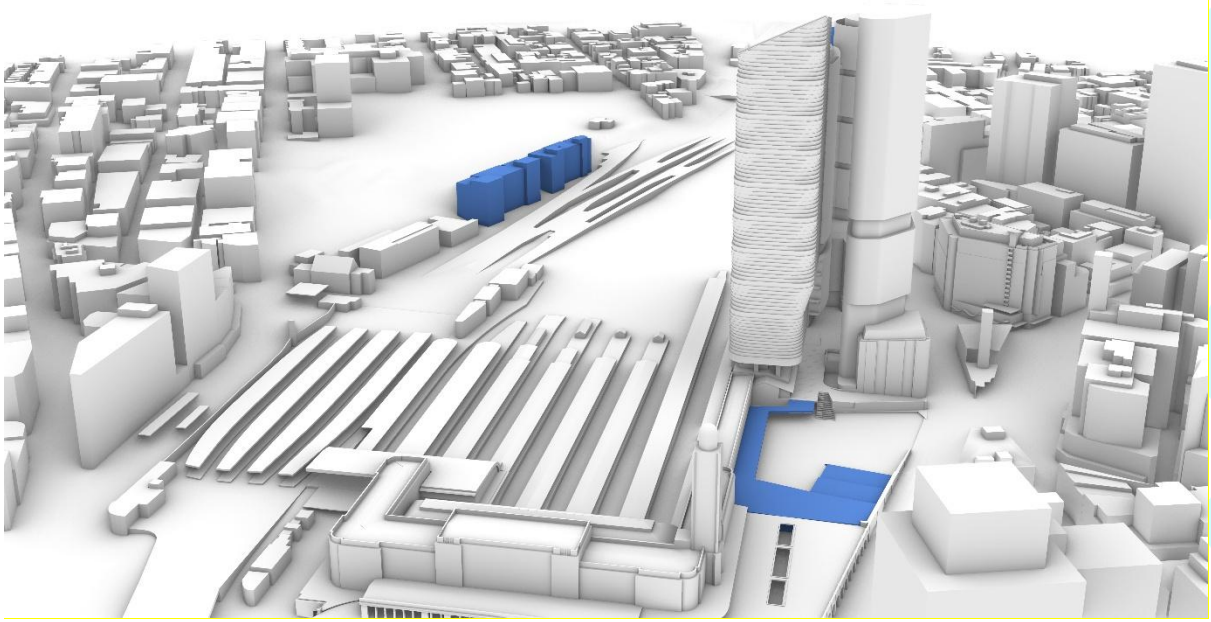

Figure 8: View from the north for Option 2 showing the Western Gateway and the proposed Regent Street Sidings

The buildings and terrain were placed into the centre of a cylindrical domain with a radius of 2500m and a height of 2000m. This resulted in a blockage ratio less than 3% and ensured the domain boundaries were sufficiently far from the buildings to have a negligible effect on the wind flow in the area of interest.

The CFD method employed requires the domain to be subdivided into computational cells where the equations are solved. The domain was meshed with both hexahedral and split-hexahedra cells which increased in resolution around buildings ensuring that there were at least 10 cells across buildings and streets. The final mesh comprised of approximately 70 million cells.

2.2 Simulation details

A total of 16 simulations were performed in 22.5° increments, with 0° representing a wind blowing directly from the north. Simulations were performed using a customised version of OpenFOAM-v2212 using a steady-state Reynolds Averaged Navier Stokes (RANS) method. Turbulence was accounted for statistically using the $k-\epsilon$ closure model which solves additional transport equations for the turbulence kinetic energy k and turbulent dissipation rate, ϵ. OpenFOAM uses a finite volume approach to discretise the equations which were solved using the SIMPLE algorithm. Second-order discretisation schemes were used for all variables.

The domain's inlet was modelled as an atmospheric boundary layer defined by AS/NZS 1170.2:2021 (Standards Australia, 2021). L2T have custom boundary conditions for the velocity, k and ϵ which matches the prescribed values accurately over the whole ABL which is discussed in detail in Appendix A. The top boundary was a slip wall and all solid surfaces were non-slip walls. Around the explicitly modelled geometry, rough wall functions with low roughness heights were used to represent elements which had not been explicitly modelled (e.g. parks, road surfaces etc), and in the far field the roughness lengths matched the terrain category of the inlet profile which varied by direction.

Convergence was assessed using a custom function which defines a change in velocity magnitude between the current iteration and iteration 200 steps previous. The solution is considered converged when the RMS value of this quantity for all the cells in the pedestrian plane falls below 10% for 2000 iterations. Additionally, the residuals, a measure of the maximum difference from one iteration to the next, had to remain below 1e-3 for pressure and 1e-4 for velocity and turbulence.

2.3 Wind climate model

To obtain a statistical understanding of the wind impact, a model of the site's climate must be developed. For this study, data was collected from the Bureau of Meteorology (BOM) Sydney Airport observation station, approximately 7km to the south-west of the site. The data consisted of 20 years of one-minute average wind speeds and directions which was down sampled to one-hour averages. The data was filtered between 6am and 10pm and was corrected to TC2 terrain category at 10m height. A wind rose which shows the strength and direction of the winds is shown in Figure 9.

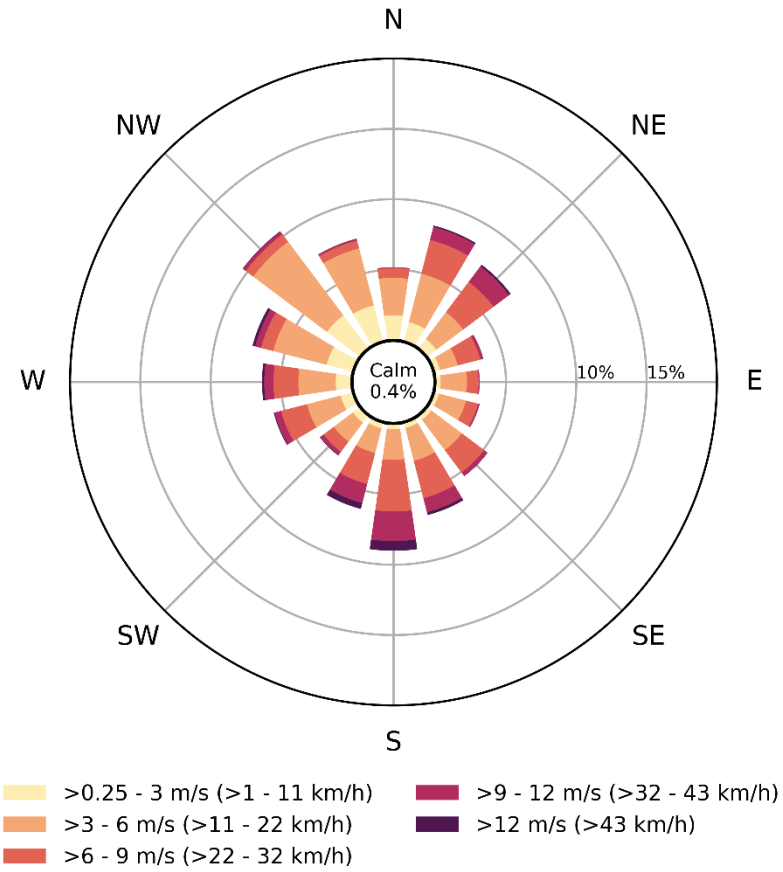

Figure 9: Annual for the Sydney Airport station, corrected to TC2 at 10m

Erroneous and suspicious data was removed and data was binned into 16 wind directions. Maximum likelihood estimation was used to fit a Weibull probability distribution to the data which has the form

$$p(u > U) = P_\theta e^{-\left(\frac{u}{c}\right)^k}$$

Where P_θ is the probability of the winds blowing from the θ direction and c and k are the scale and shape parameters of the distribution, respectively. The c parameter was scaled to account for the

differences in terrain around the airport and the site, using the method outlined in AS1170.2 (Standards Australia, 2021). The site-specific climate model was then combined with the local wind flow computed by the CFD to determine the probability of a wind speed being exceeded.

2.4 Assessment criteria

The City of Sydney DCP 2012, Section 5.1.9 prescribes the criteria for wind comfort and safety which are applicable to this study and are reproduced in Table 1 These criteria are aligned with the Central Precinct Design Guide, Schedule 1, and are based on a 5% exceedance between 6am and 10pm.

Table 1: Comfort criteria used in the study

Criteria	Max wind speed (m/s)
Sitting	4
Standing	6
Walking	8

The safety criterion is defined as an annual maximum 0.5 second gust wind speed of 24m/s, in one hour, measured between the hours of 6am – 10pm.

Target wind conditions are prescribed in the Central Precinct Design Guide, Section 8.3, for various publicly accessible spaces within the Precinct and surrounding public spaces.

3. RESULTS

Results are presented in this section for the safety and comfort criteria as defined in Section 2.3. Results for individual directions are presented in Appendix B.

3.1 Safety

Figure 10 shows contours of the safety criterion on a plane 1.5m above the ground for the existing scenario. There are exceedances of the safety criterion in Henry Deane Plaza in the Western Gateway to the south of Block C (TOGA Central), as well as at ground level on the corner of Little Regent Street and Lee Street.

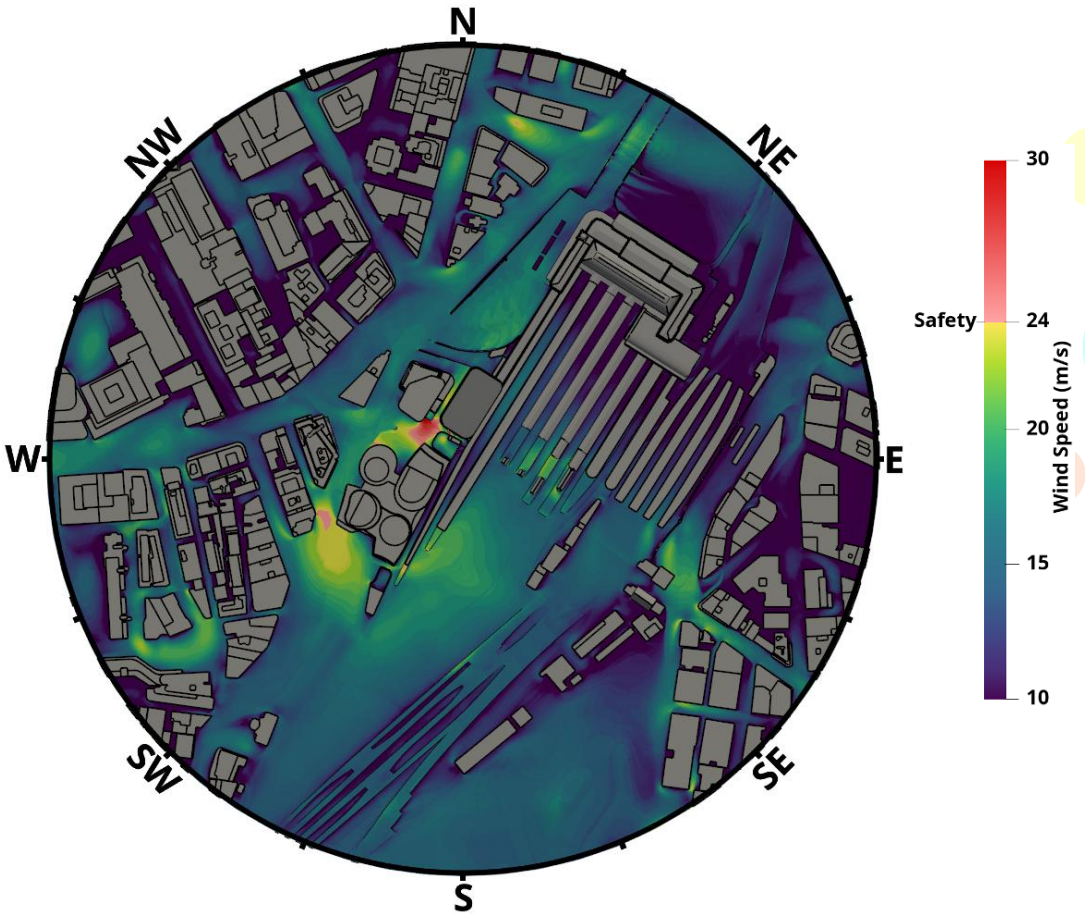

Figure 10: Contours of safety criteria on a plane 1.5m above ground for the existing scenario

Figure 11 shows contours of the safety criterion on a plane 1.5m above ground for the proposed Option 1 scenario, including the commercial scheme at Regent Street Sidings. There are exceedances of the safety criterion in Henry Deane Plaza in the Western Gateway to the south of Block C, however the extent of the exceedance is not significantly larger than in the existing

condition. There is no exceedance of the safety criteria on the corner of Lee Street and Little Regent Street.

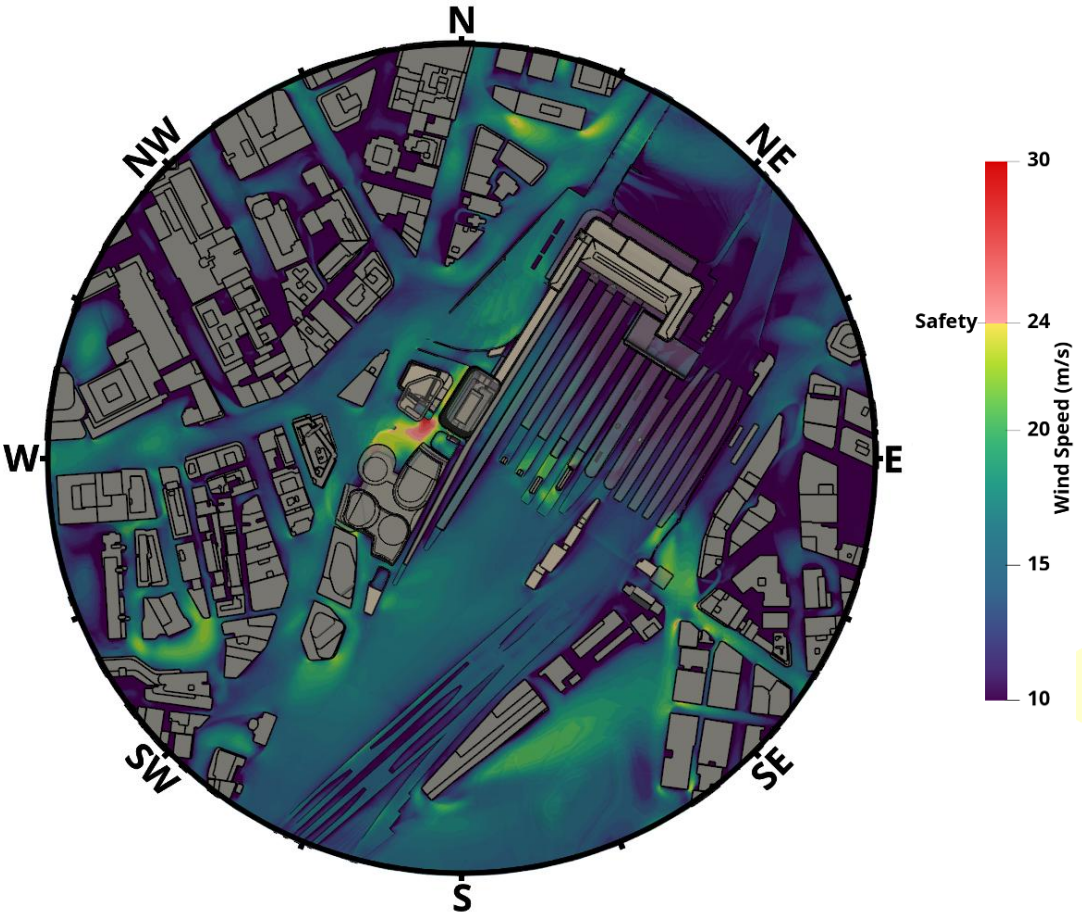

Figure 11: Contours of safety criteria on a plane 1.5m above ground for Option 1

Figure 12 shows contours of the safety criteria on a plane 1.5m above the ground for the proposed Option 2 scenario, including the residential scheme at Regent Street Sidings. There are exceedances of the safety criterion in Henry Deane Plaza in the Western Gateway to the north of Block A (Atlassian Central) and to the south of Block C. The scale of the exceedance to the south of Block C is no worse than the existing condition.

The area of exceedance to the north of Block A is due to the introduction of the walkway above Central Square leading to the Western Forecourt as shown in Figure 13. This may be mitigated at DA stage with the inclusion of balustrades and/or localised mitigation measures.

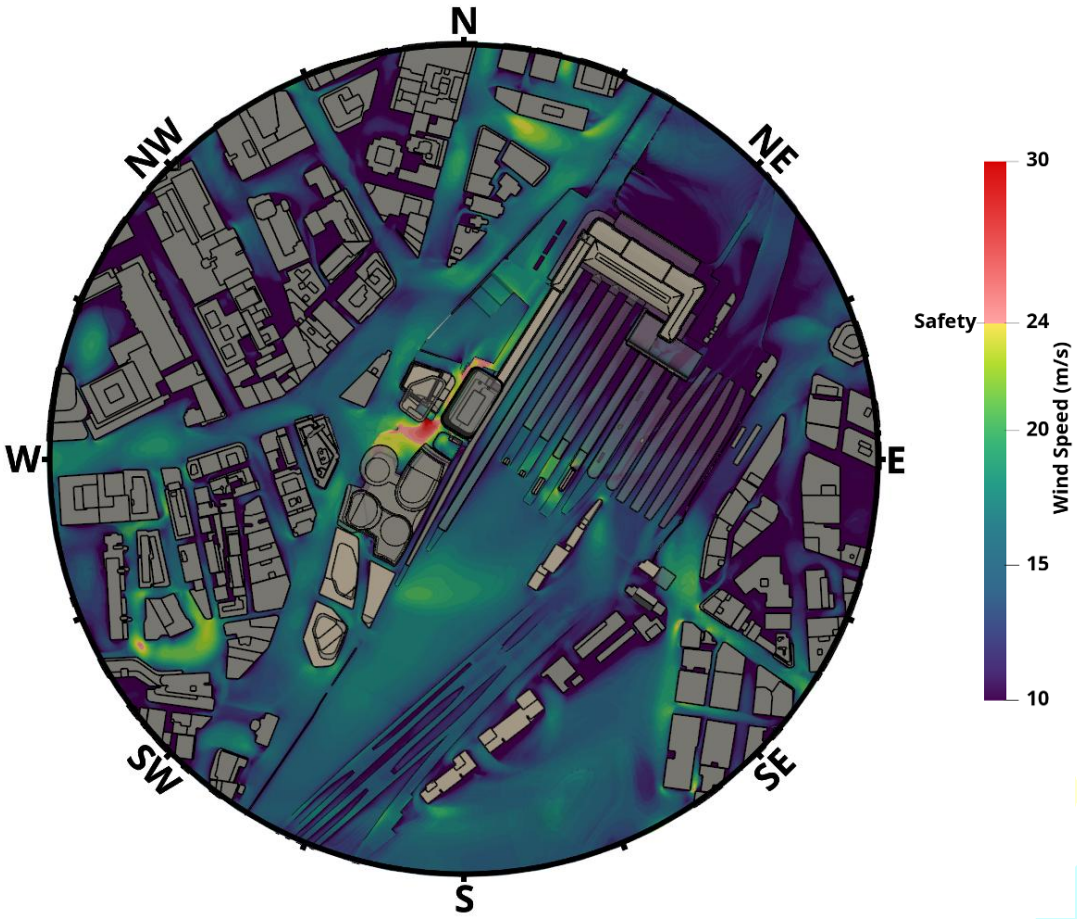

Figure 12: Contours of safety criteria on a plane 1.5m above ground for Option 2

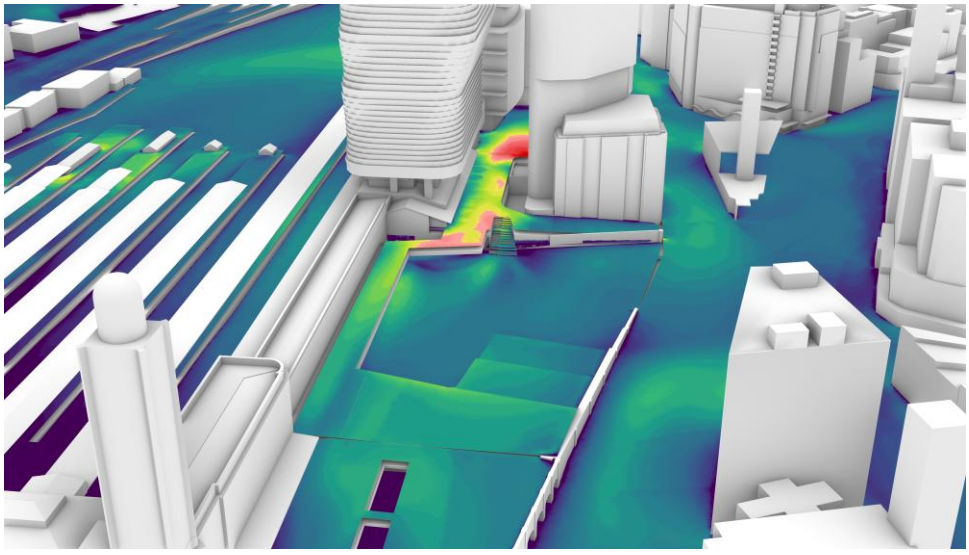

Figure 13: Detail of the area of safety criteria exceedance on the walkway above the Central Square

3.2 Comfort

Figure 14 shows contours of the comfort criteria on a plane 1.5m above the ground for the existing scenario. It shows that most spaces meet their target wind comfort conditions as prescribed by the Design Guide with the exception of Mortuary Station Gardens which achieves standing and walking criteria, against a target of "Predominantly standing criteria [and] localised sitting criteria in the northern half of the gardens".

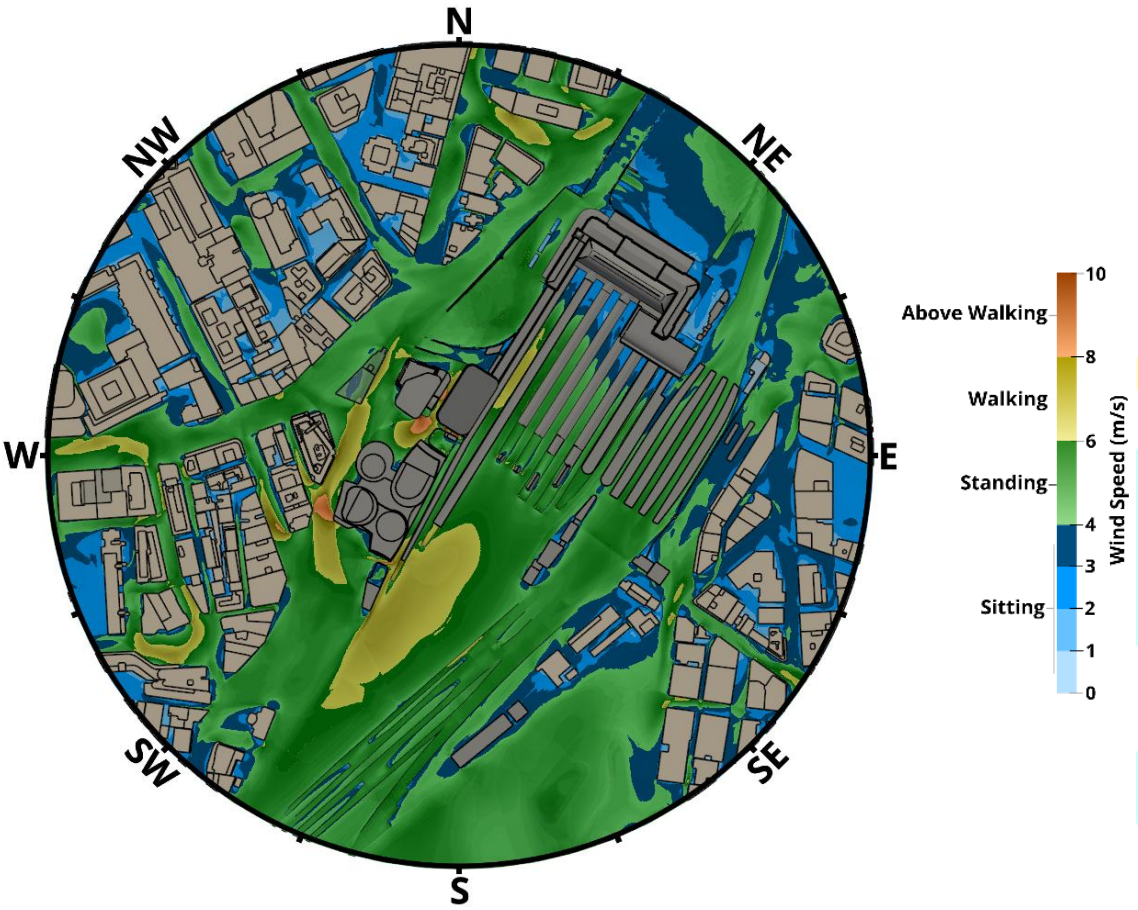

Figure 14: Contours of comfort criteria on a plane 1.5m above ground for the existing scenario

Figure 15 shows contours of comfort criteria on a plane 1.5m above ground for the proposed Option 1 scenario. Conditions meet the target comfort criteria with the exception of Mortuary Station Gardens, and Prince Alfred Park, which has a small section where walking criteria are achieved, which is a category above the existing condition. If required, this can be mitigated at DA stage with localised hard and soft landscaping.

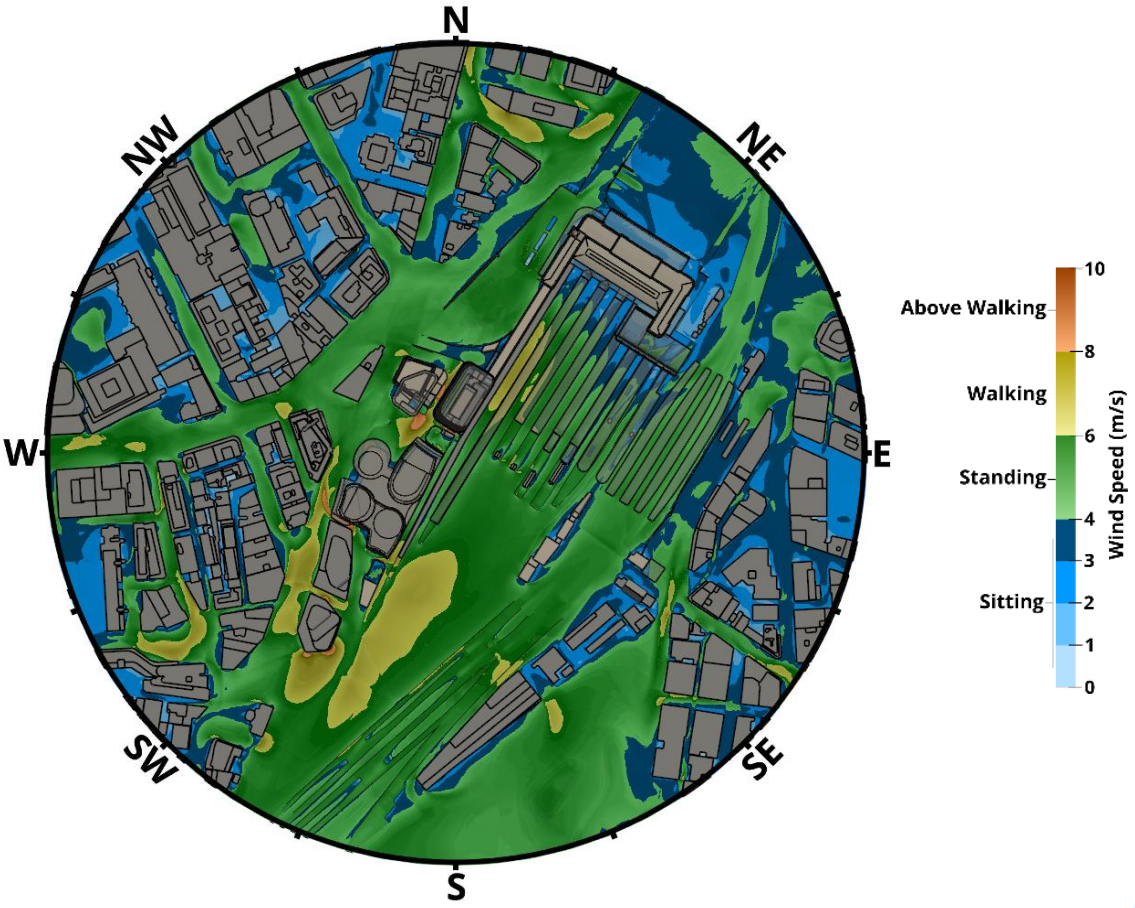

Figure 15: Contours of comfort criteria on a plane 1.5m above ground for Option 1

Figure 16 shows contours of comfort criteria on a plane 1.5m above ground for the proposed Option 2 scenario. Conditions meet the target wind comfort criteria around the site, with the exception of Mortuary Station Gardens.

Compared with results including the OSD, conditions in Mortuary Station Gardens are windier due to the absence of shielding from north-easterly winds. Figure 17 shows streamlines of integrated velocity for the north-east wind direction which shows the impact of the building's mass on the downwash and acceleration of wind into Mortuary Station Gardens. It is recommended that a built-form solution, combined with localised soft and hard landscaping, is investigated at DA stage to mitigate these winds.

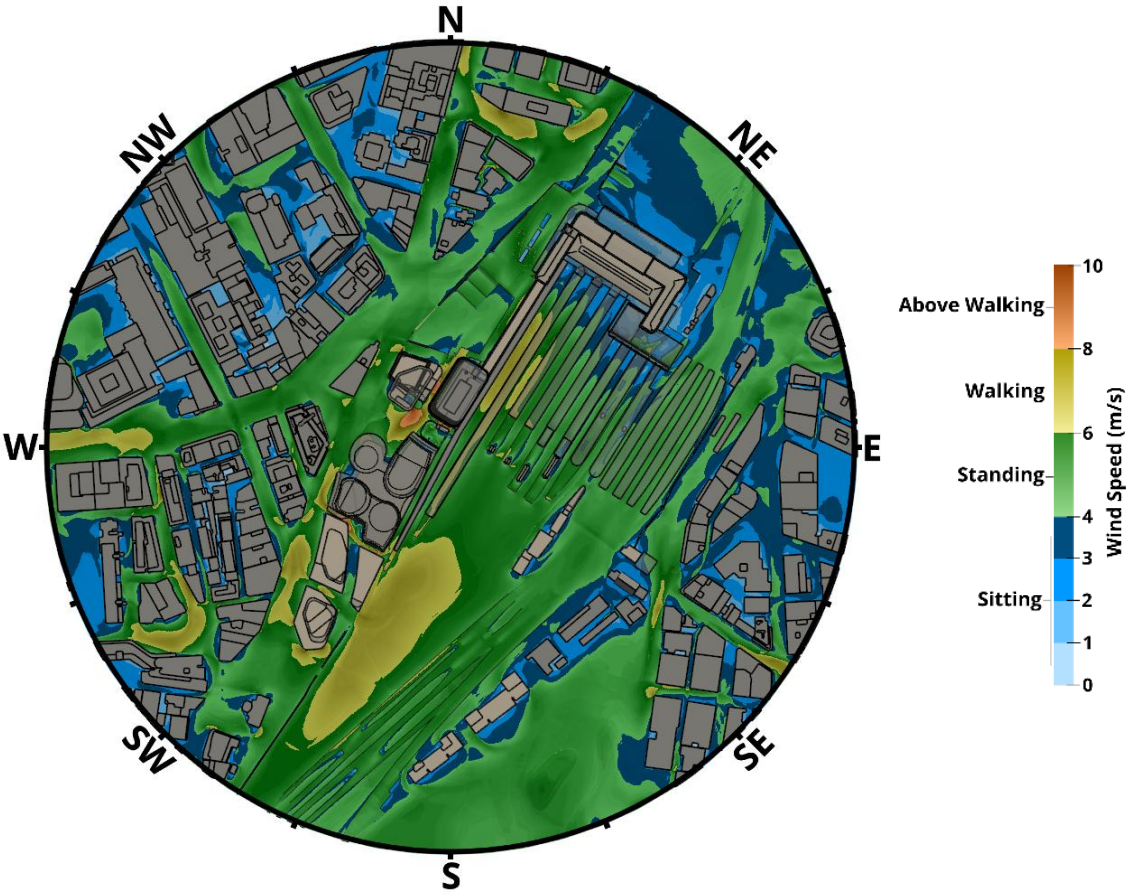

Figure 16: Contours of comfort criteria on a plane 1.5m above ground for the Option 2

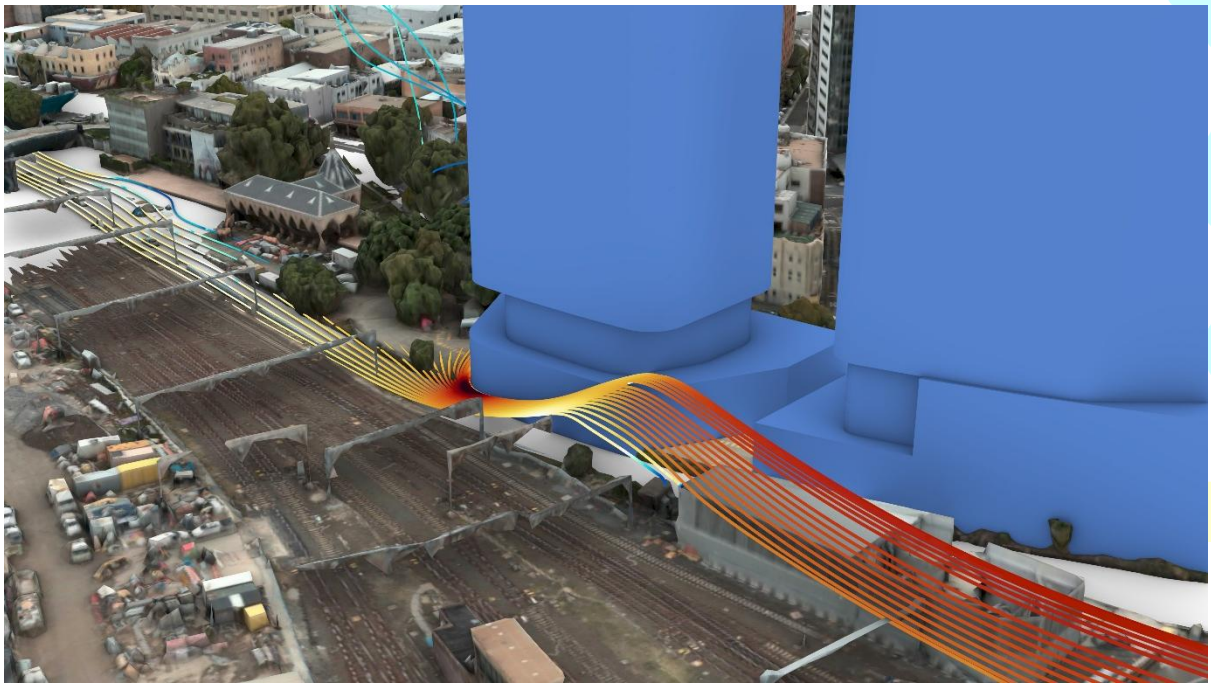

Figure 17: Streamlines of integrated velocity for the north-east wind direction

4. CONCLUSIONS AND RECOMMENDATIONS

An environmental wind impact assessment has been performed for the finalisation of the rezoning proposal for Central Station Precinct which involves removal of the Over Station Deck (OSD) and a residential scheme for Prince Alfred sidings using computational fluid dynamics (CFD). A wind assessment as defined in the City of Sydney DCP (2012), Section 5.1.9. was performed for the existing condition and future proposed configurations.

The CFD wind assessment showed that all public open spaces satisfied the wind safety criterion except for a small area to the north of Western Gateway Block A (Atlassian Building) due to the introduction of the raised walkway as part of the Central Square redevelopment proposal.

In terms of pedestrian comfort, all areas are aligned with the recommended Central Precinct Design Guidelines except for northern half of Mortuary Square Gardens which exceed the desired localised sitting wind comfort criterion.

For the exceedance of the safety criteria to the north of Block A, further assessment and development of localised mitigation measures at Development Application (DA) stage is recommended. Similarly, a built-form and/or hard landscaping solution to the Regent Street Sidings aimed at reducing wind conditions in Mortuary Square Gardens should be developed.

It is recommended that the Central Precinct Design Guidelines be updated to remove references to the OSD specifically Section 8.3 Wind safety and comfort.

This assessment appends previous study by L2T on the RTS which was summarised in *Report 64-20-CFD-ENV-04.*

5. REFERENCES

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APPENDIX A: TECHNICAL DETAILS

This appendix details some of the details and assumptions used in the assessment, in line with the reporting requirements in Section 14 of the QAM (AWES, 2024). Whilst many of these have been reported in the main report, additional technical detail is presented here.

Wind speed definition

In a RANS simulation, the average velocity is defined as the magnitude of the mean components of velocity:

$$V_{mag} = \sqrt{\bar{\bar{U}}^2 + \bar{\bar{V}}^2 + \bar{\bar{W}}^2}$$

However, this quantity differs from the time-average of the instantaneous magnitude commonly measured in the wind tunnel which is the quantity that is most relevant for pedestrian winds. This is estimated in the CFD by using the turbulent kinetic energy to define a mean wind speed (Smirnov, Ivanov, Telnov, Son, & Aksamentov, 2004):

$$V_{mean} = \sqrt{V_{mag}^2 + \frac{5}{3}k}$$

Additionally, the criteria is based on both the mean wind speed and the gust wind speed. By assuming that the probability distribution of winds in the urban canopy doesn't vary spatially so that the gust speed is:

$$U_g = V_a + K\sigma$$

where K is a gust factor that varies between $K = 3 \rightarrow 3.7$ and σ is the standard deviation which is related to the turbulent kinetic energy, k, from the RANS simulation through

$$\sigma = \sqrt{\frac{2}{3}k}$$

The gust speed is converted to a GEM dividing the gust wind speed by 1.85.

ABL modelling

The most recent Standard has changed from defining an equation for the inlet velocity and turbulence to using tabulated values. However, the underlying profiles are based on the Deaves and Harris model of the atmospheric boundary layer (Deaves & Harris, 1978). L2T's profile uses

the Deaves and Harris model up to the linear term and have developed a method to maintain the velocity and turbulence profiles throughout the domain.

As required by the QAM (AWES, 2024), Figures Figure A 1 to Figure A 4 shows the measured profile in an empty domain for TC1-TC4. It shows that the ABL implementation exhibits excellent horizontal homogeneity and accuracy.

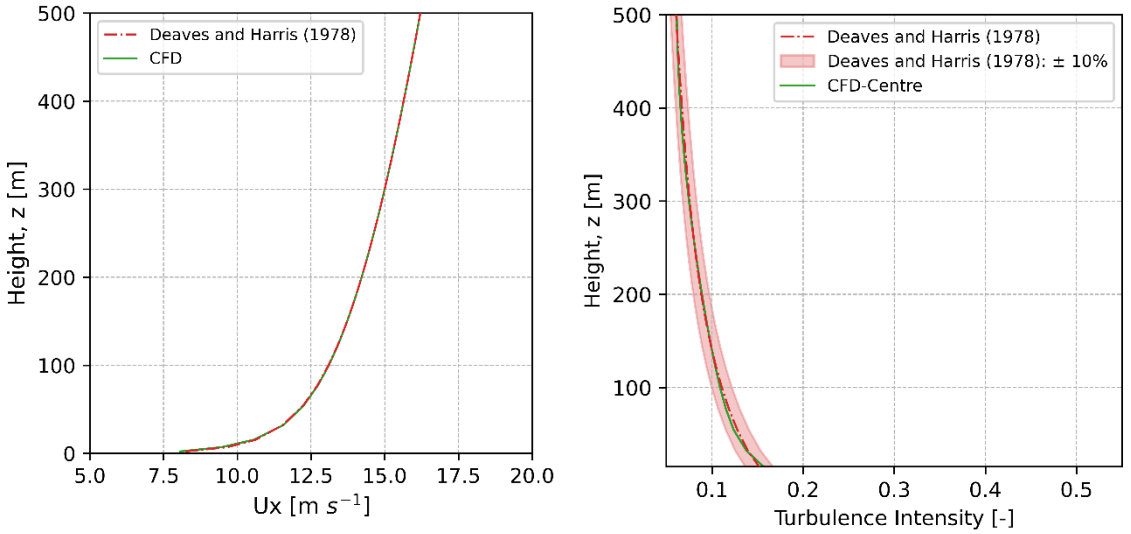


Figure A 1: Measured velocity and turbulence intensity profiles for TC1, compared to target.

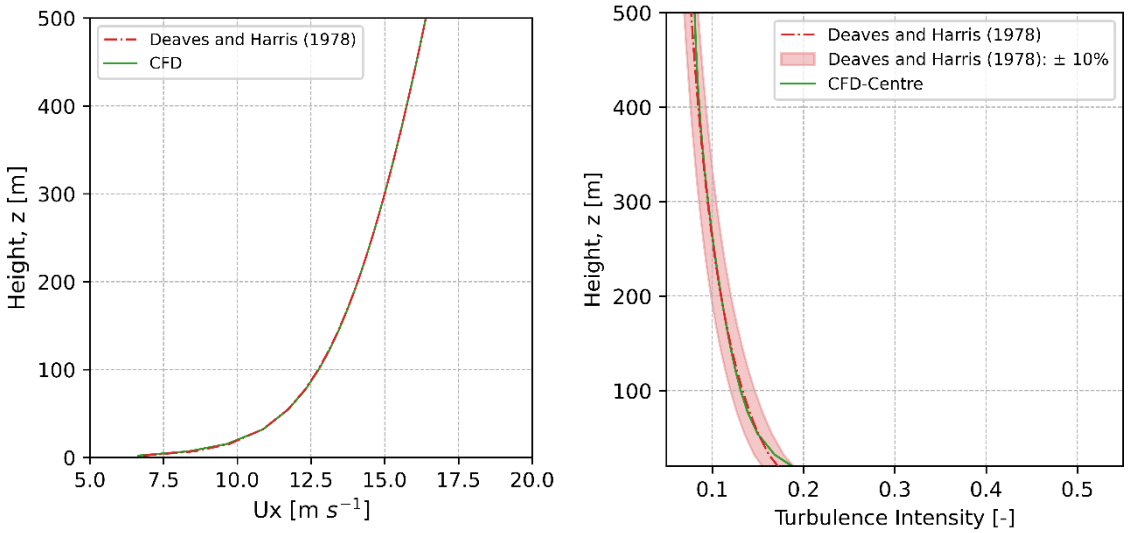


Figure A 2: Measured velocity and turbulence intensity profiles for TC2, compared to target.

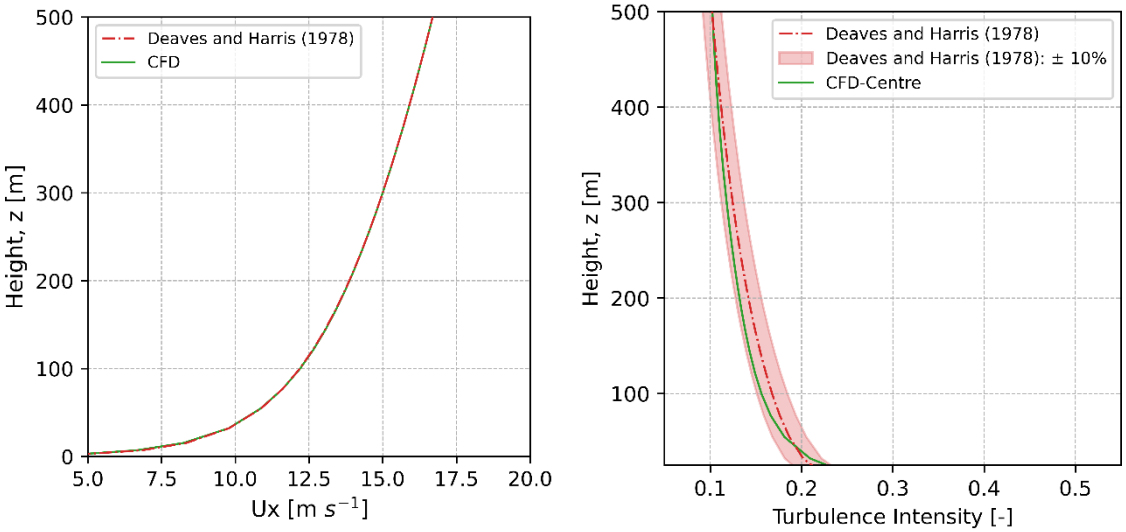


Figure A 3: Measured velocity and turbulence intensity profiles for TC3, compared to target.

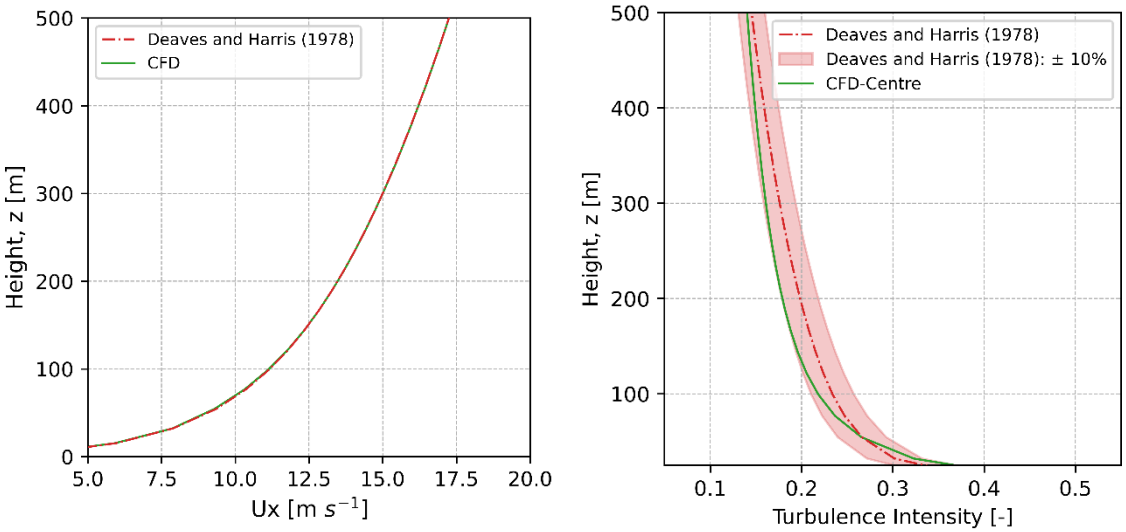


Figure A 4: Measured velocity and turbulence intensity profiles for TC4, compared to target.

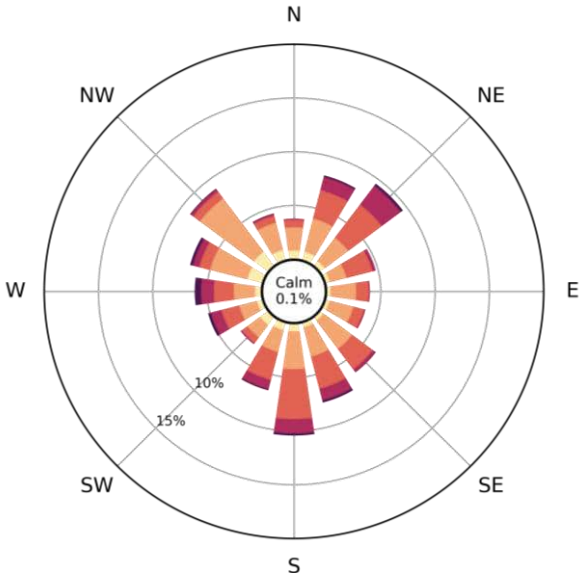
APPENDIX B: DIRECTIONAL PLOTS

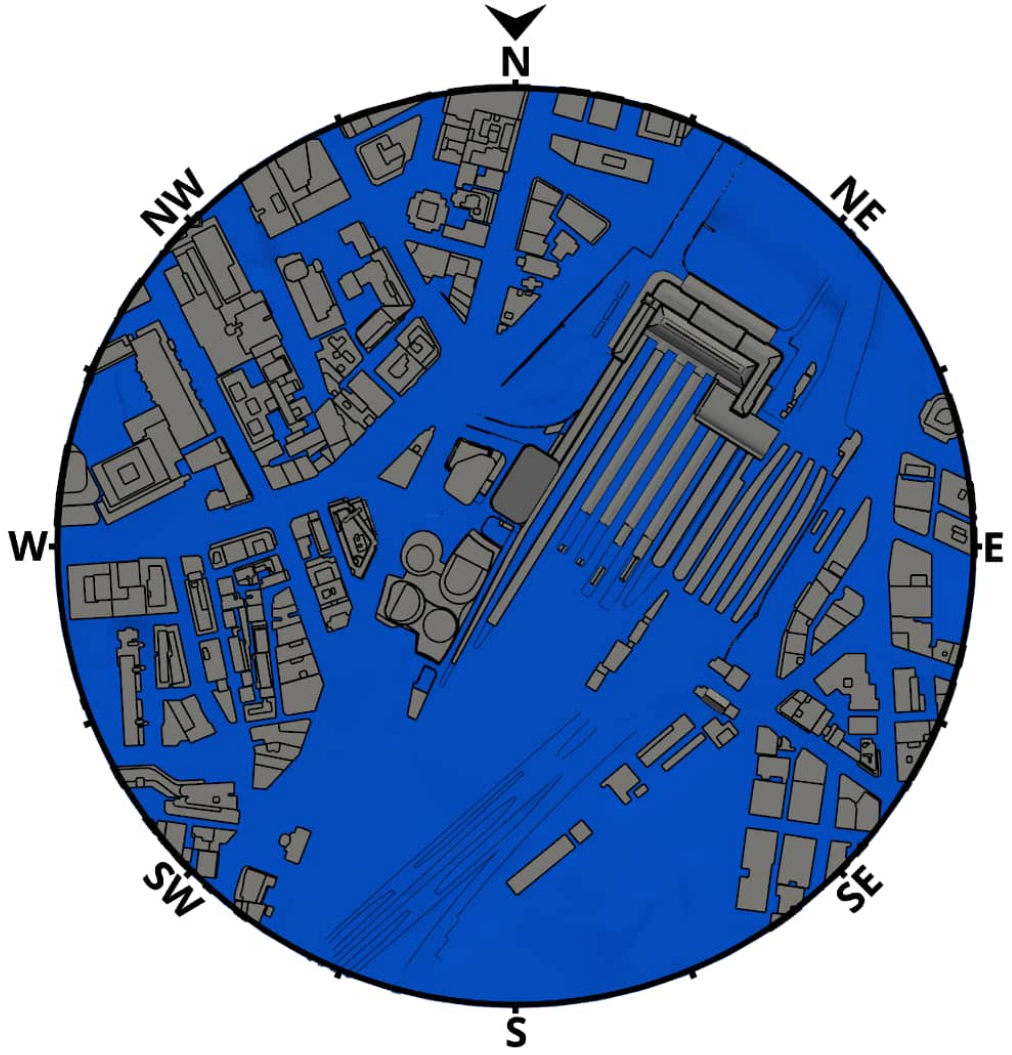
The following pages present contours of safety and comfort on a plane 1.5m above for each direction simulated for all scenarios. The results presented in the report are the sum of all these wind directions.

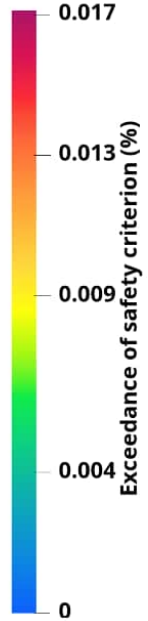
Existing - Directional Contributions - Safety

SAFETY CRITERIA - NORTH CONTRIBUTION - PLANVIEW - ANNUAL

Existing

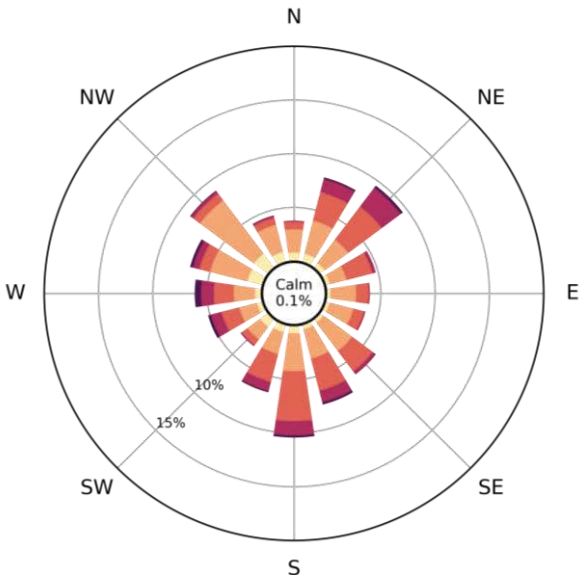


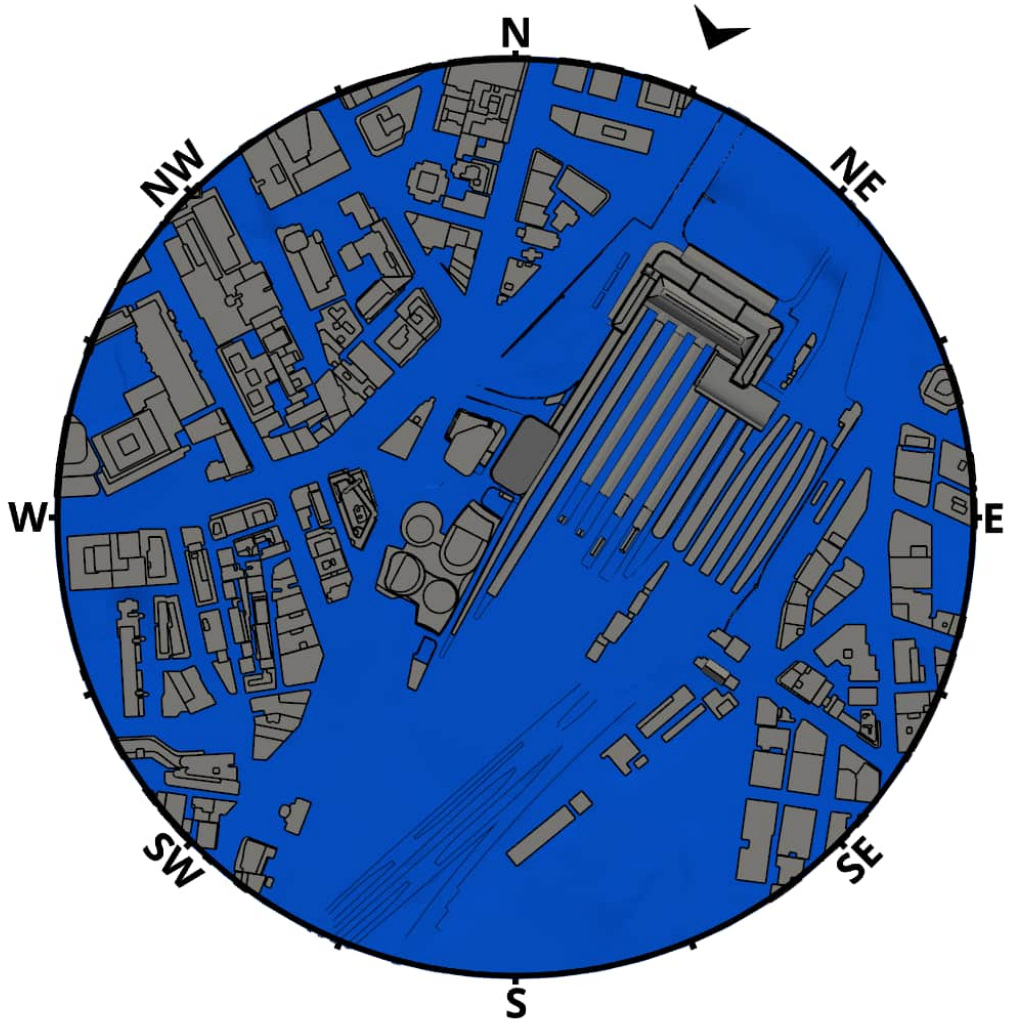


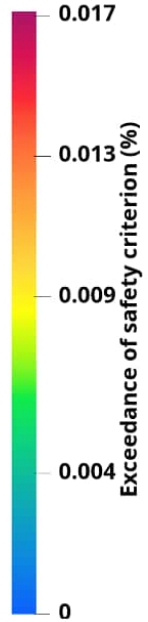


SAFETY CRITERIA - NORTH-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Existing







SAFETY CRITERIA - NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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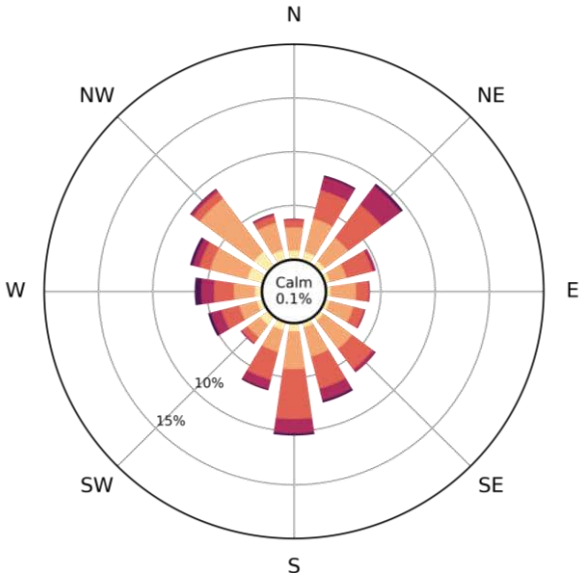

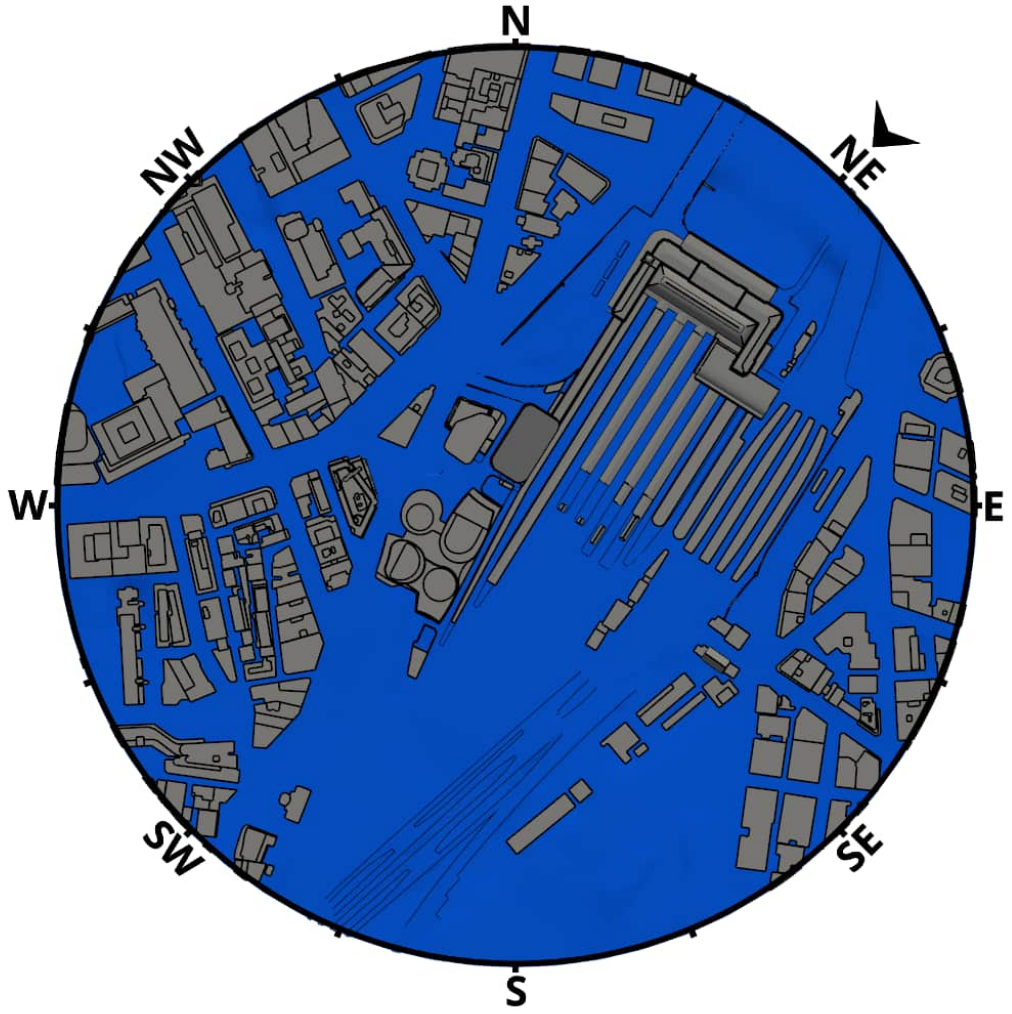

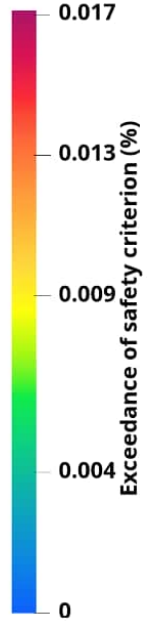

SAFETY CRITERIA - EAST-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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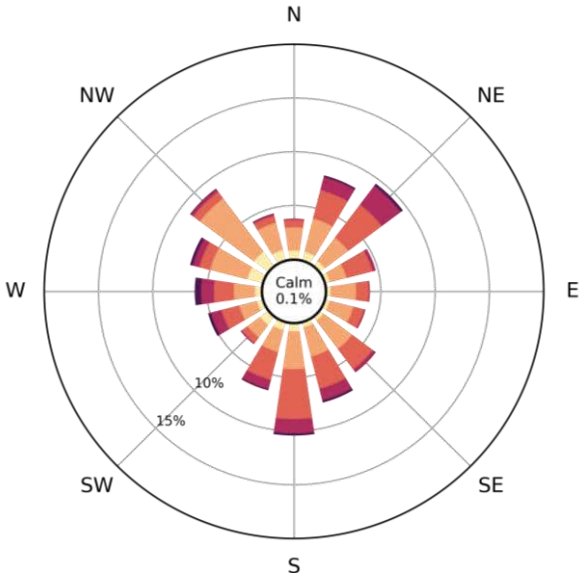

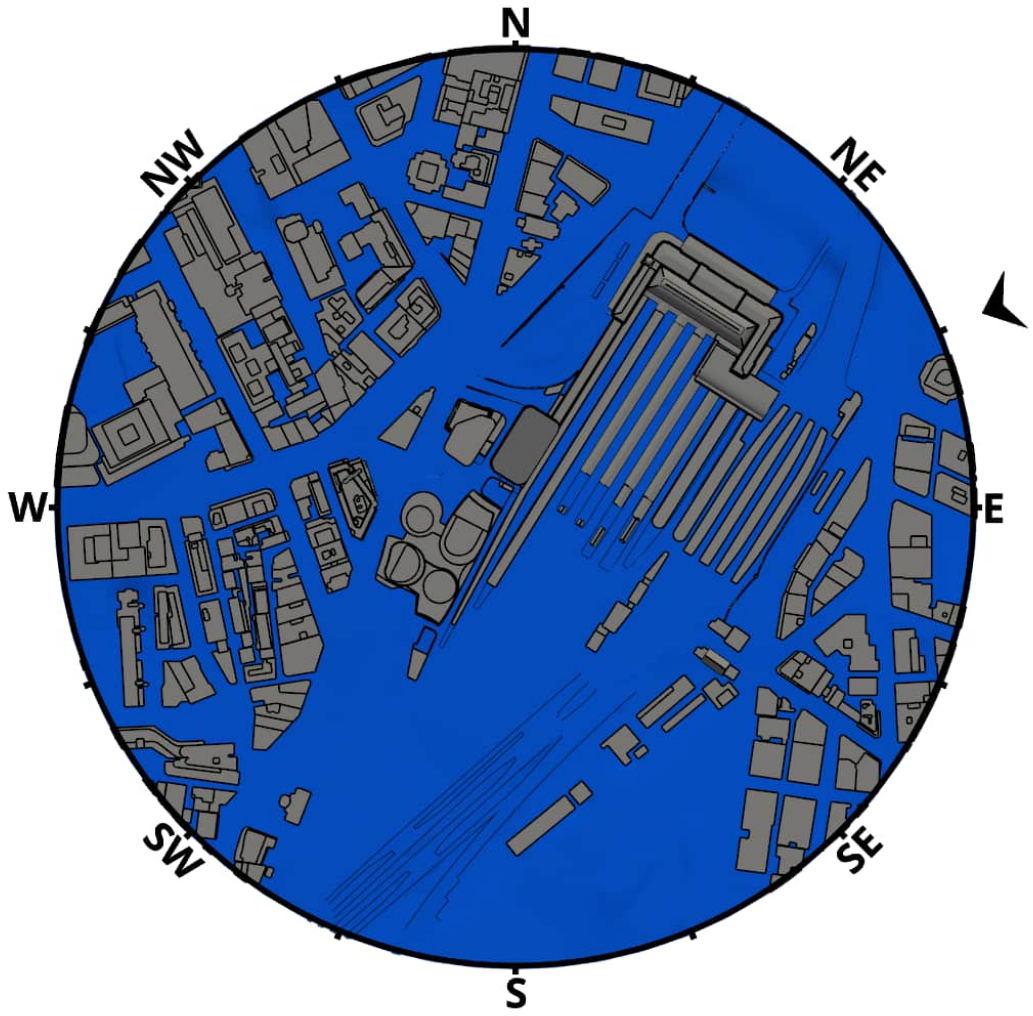

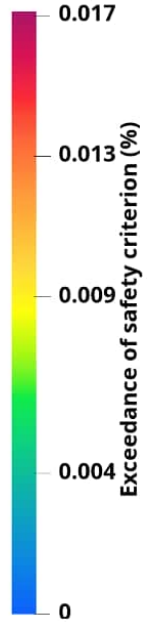

SAFETY CRITERIA - EAST CONTRIBUTION - PLANVIEW - ANNUAL

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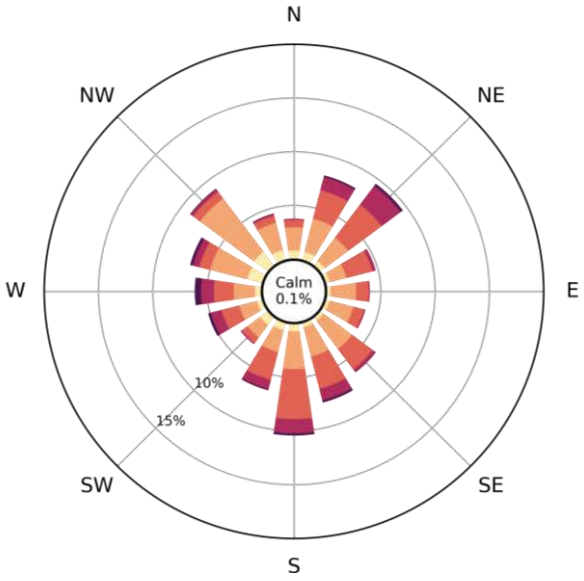

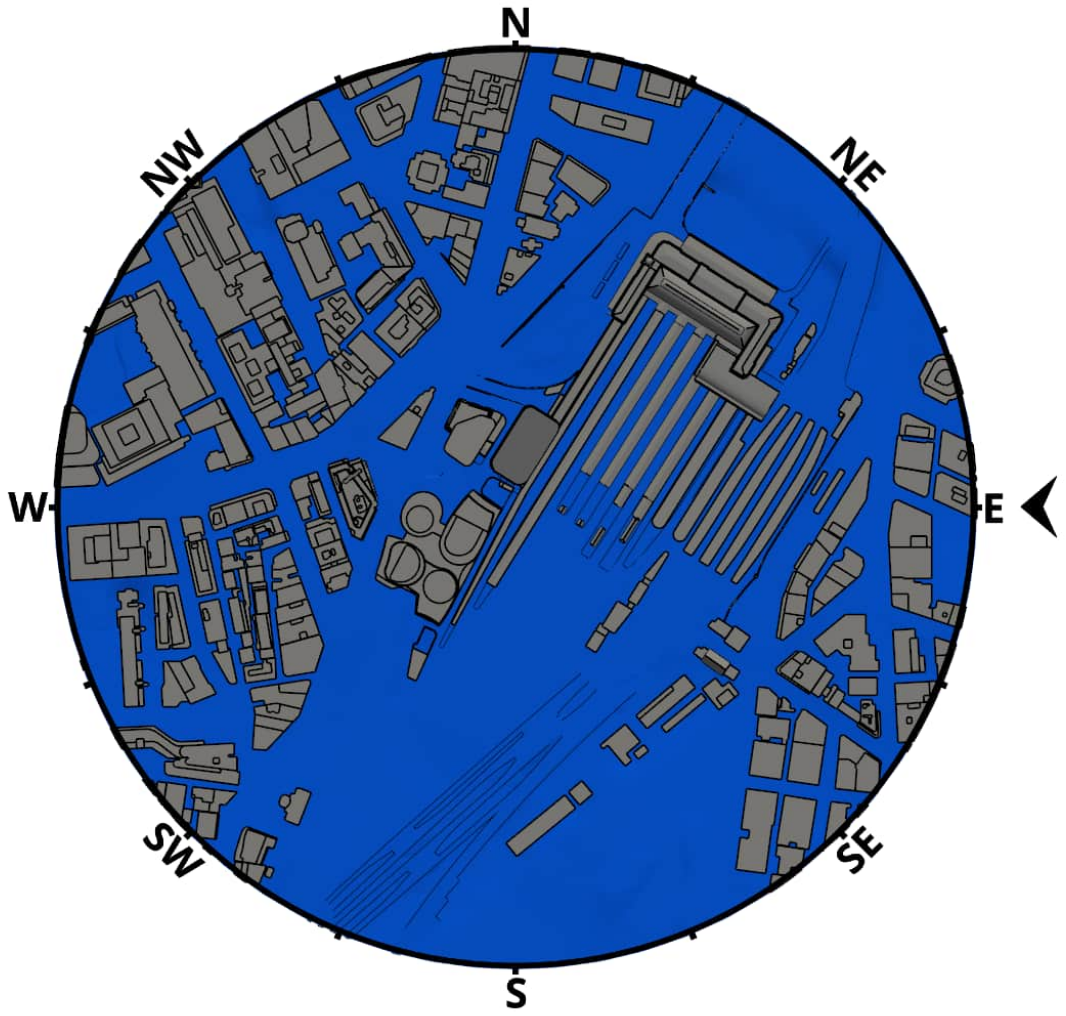

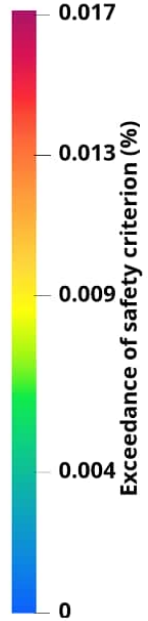

SAFETY CRITERIA - EAST-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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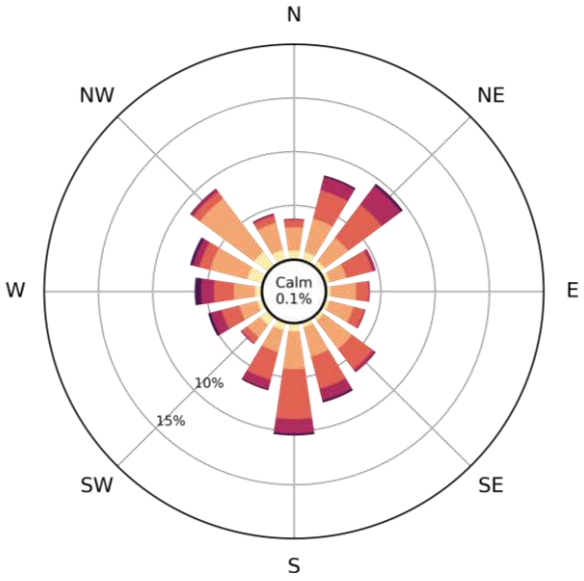

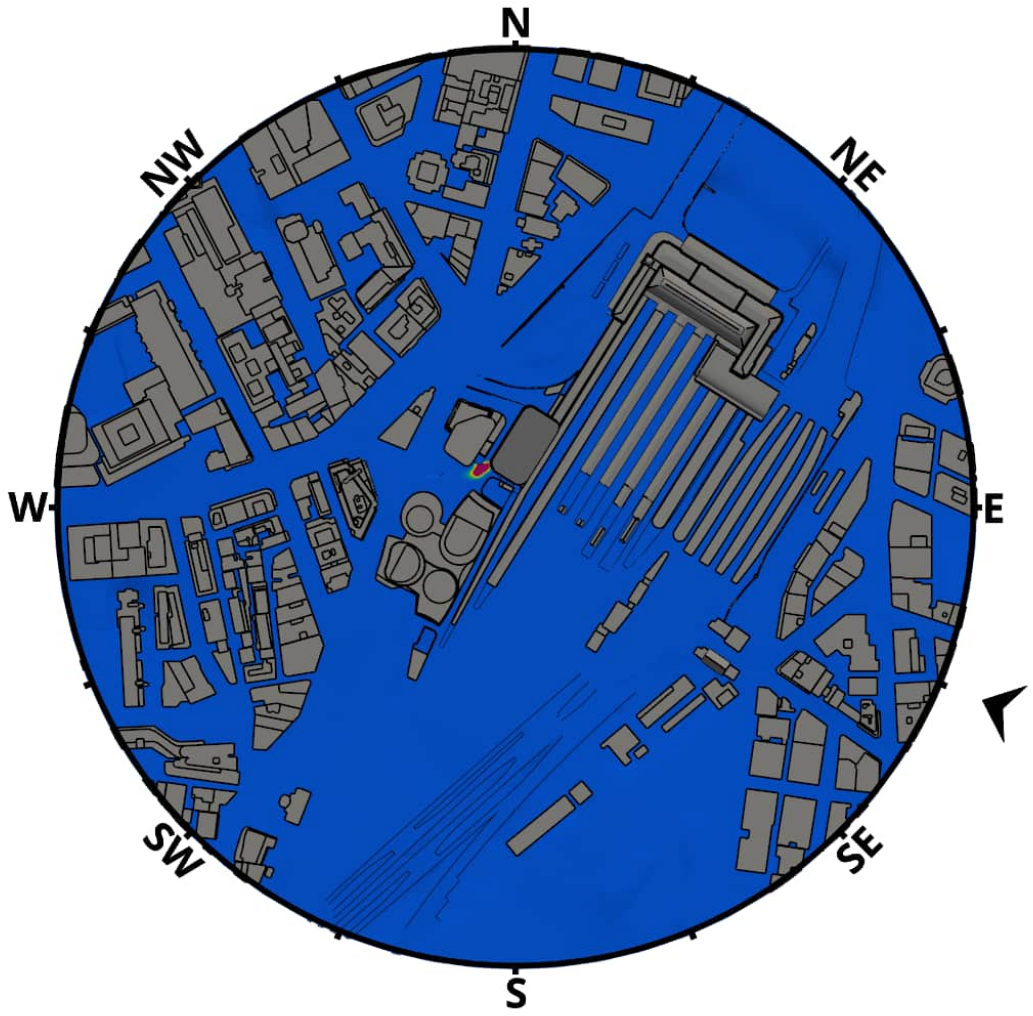

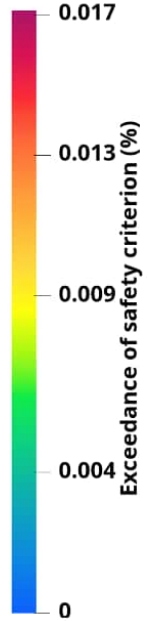

SAFETY CRITERIA - SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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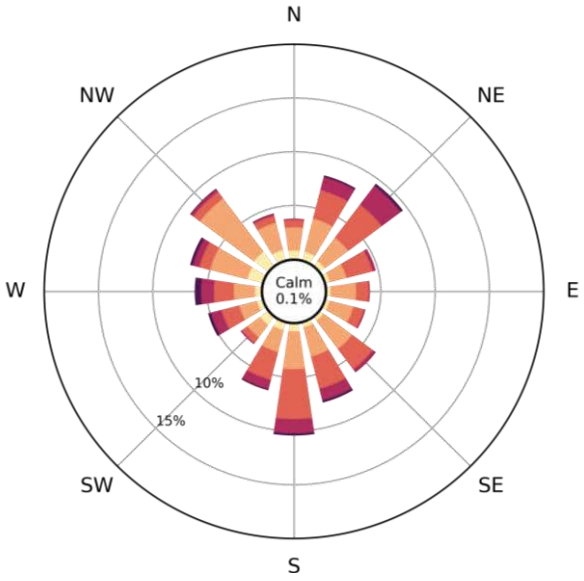

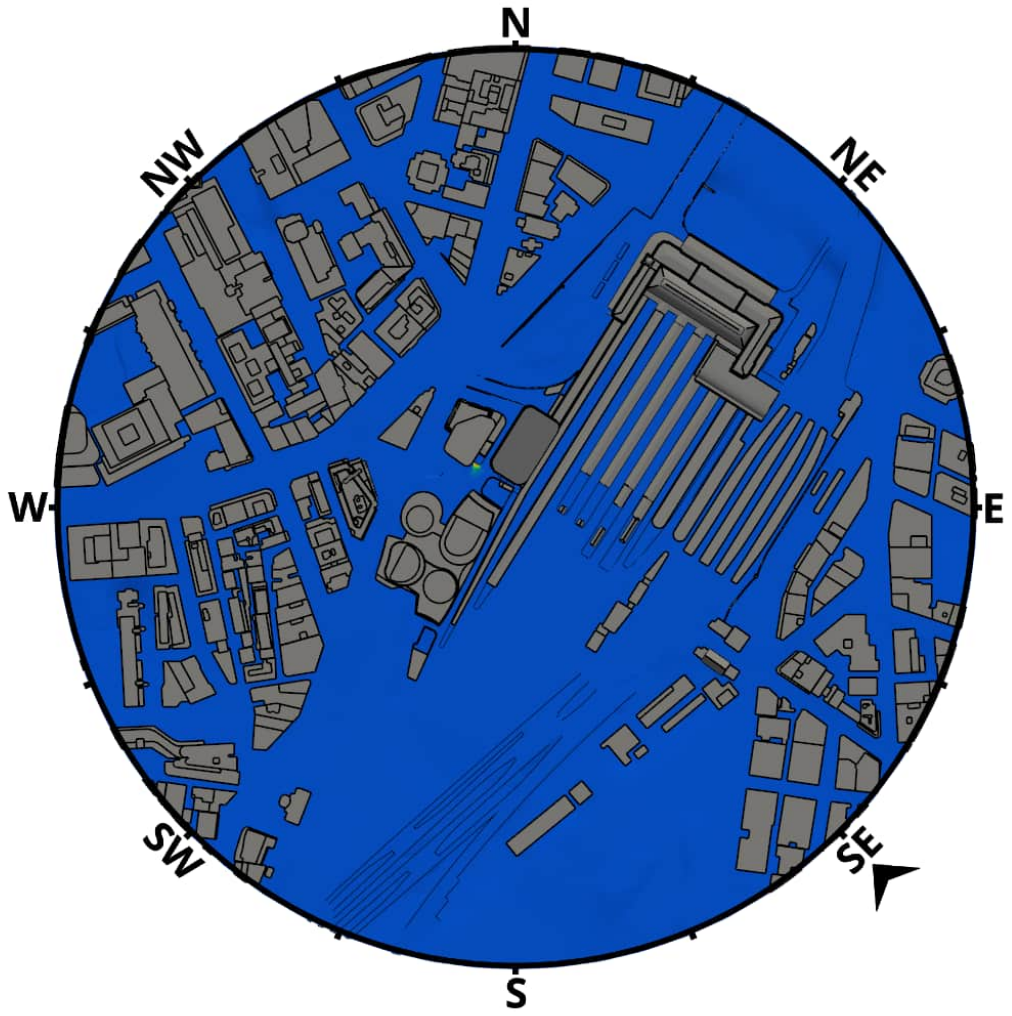

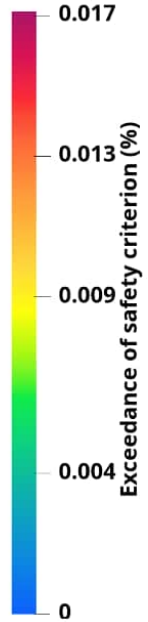

SAFETY CRITERIA - SOUTH-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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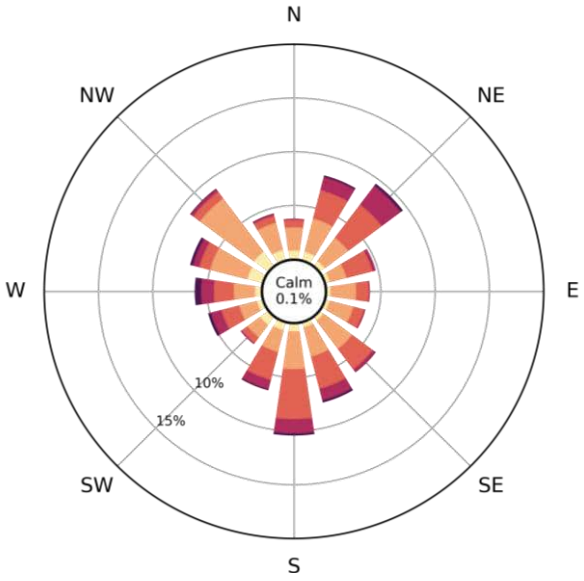

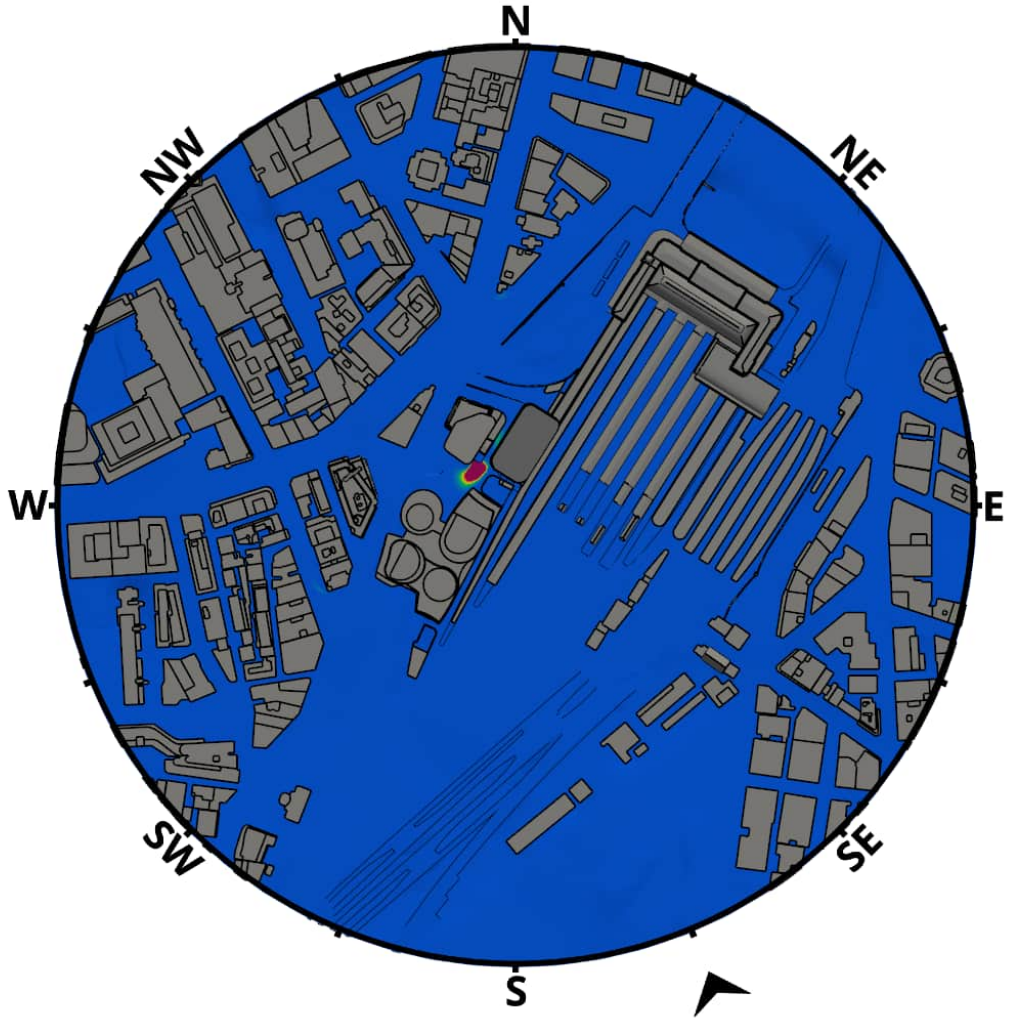

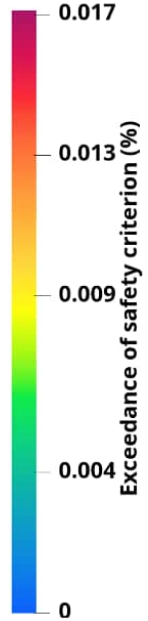

SAFETY CRITERIA - SOUTH CONTRIBUTION - PLANVIEW - ANNUAL

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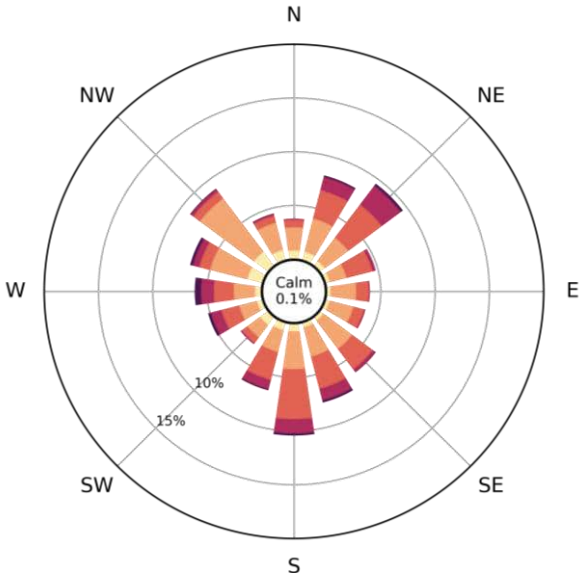

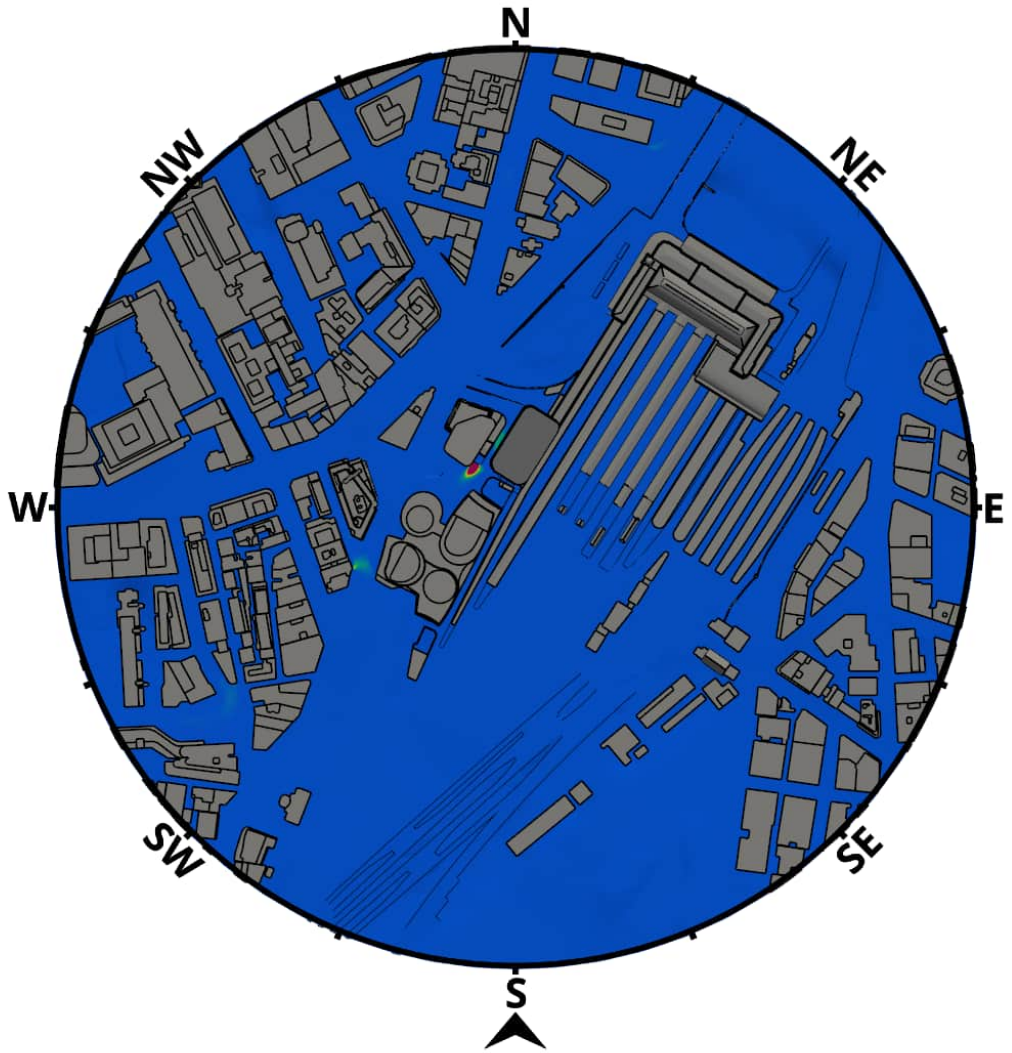

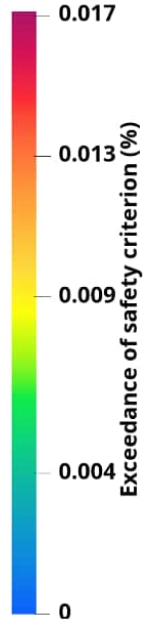

SAFETY CRITERIA - SOUTH-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

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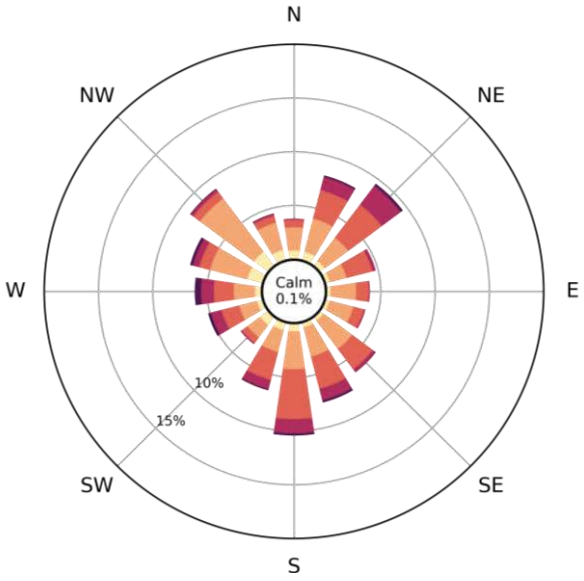

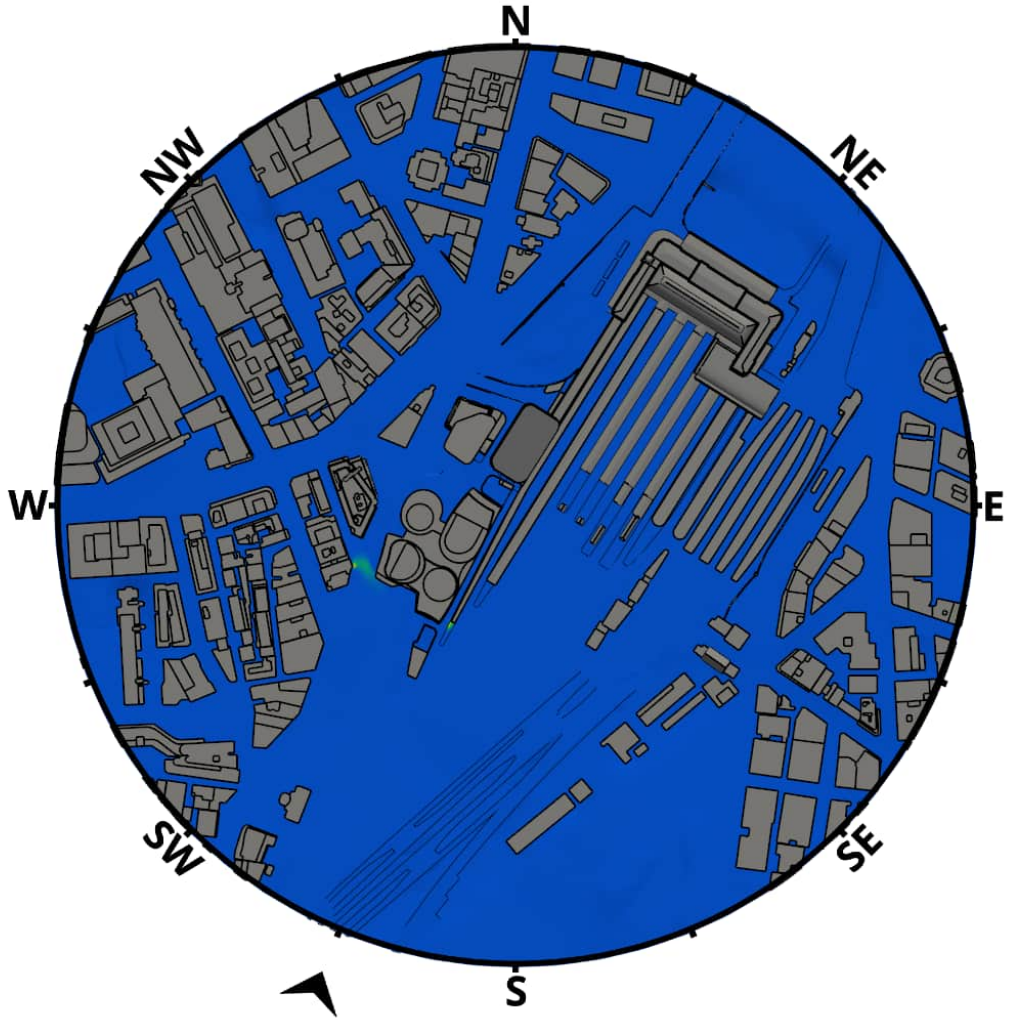

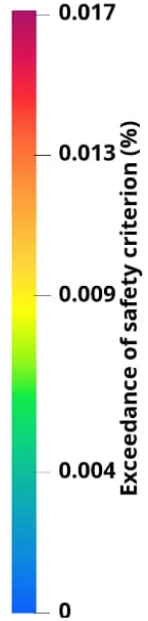

SAFETY CRITERIA - SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

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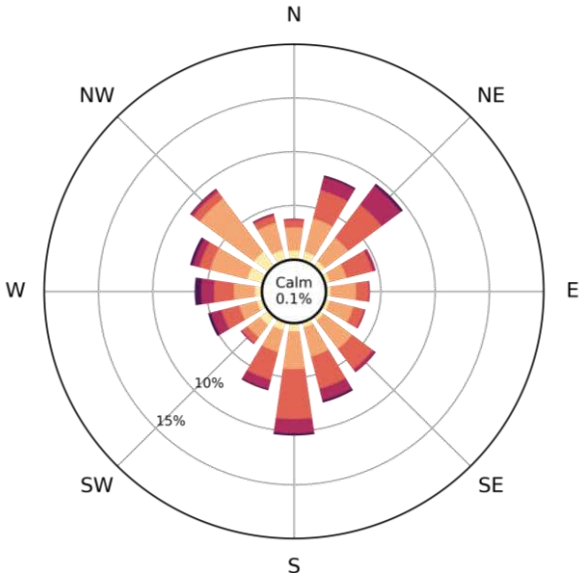

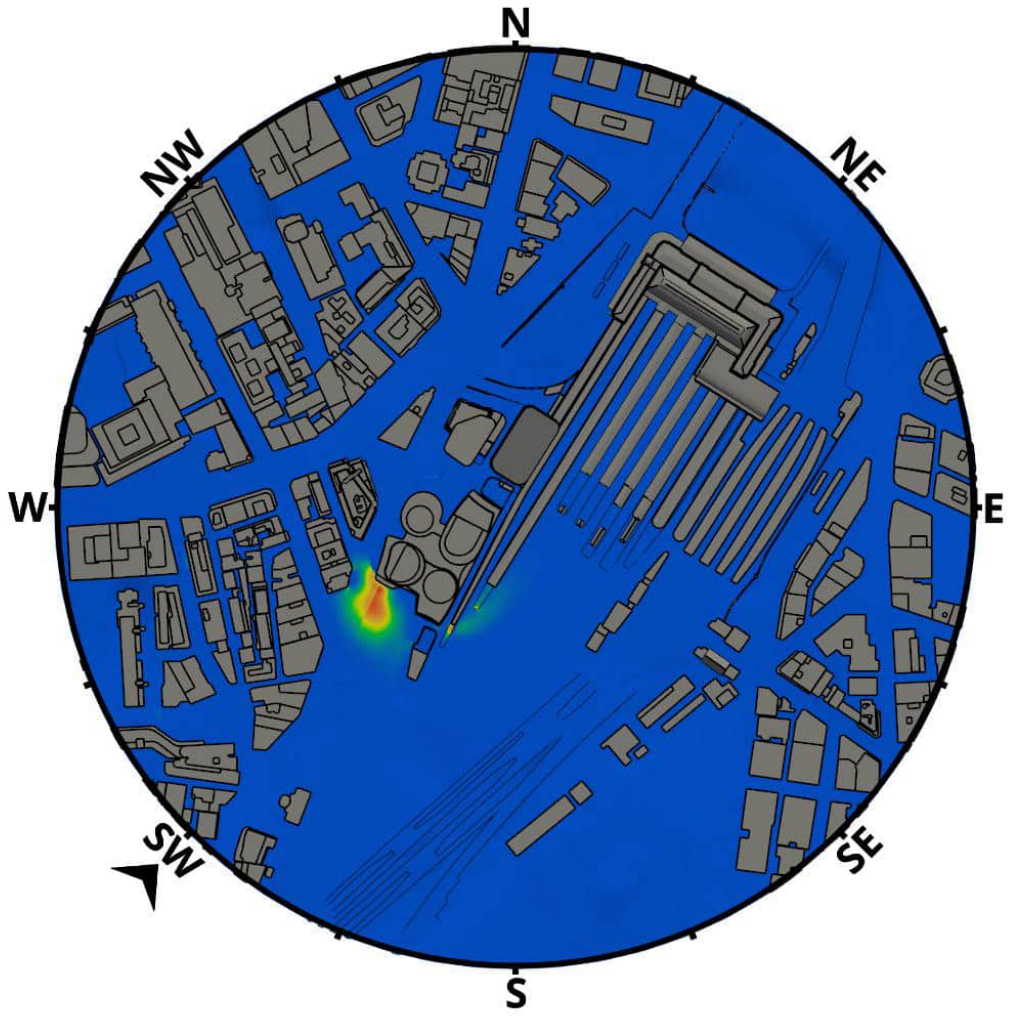

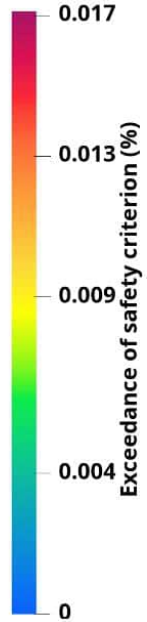

SAFETY CRITERIA - WEST-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

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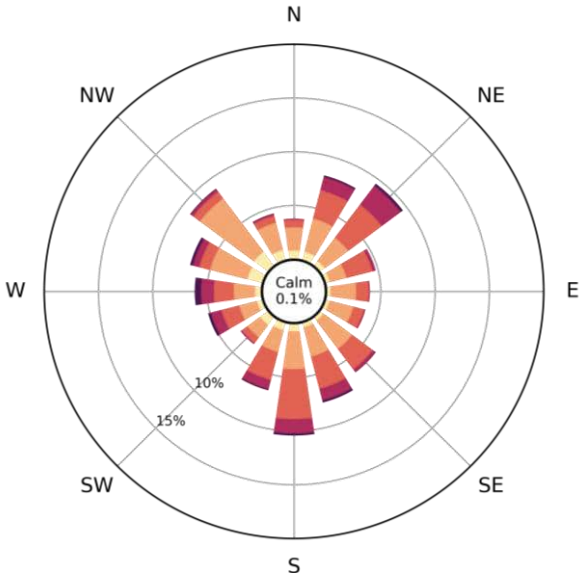

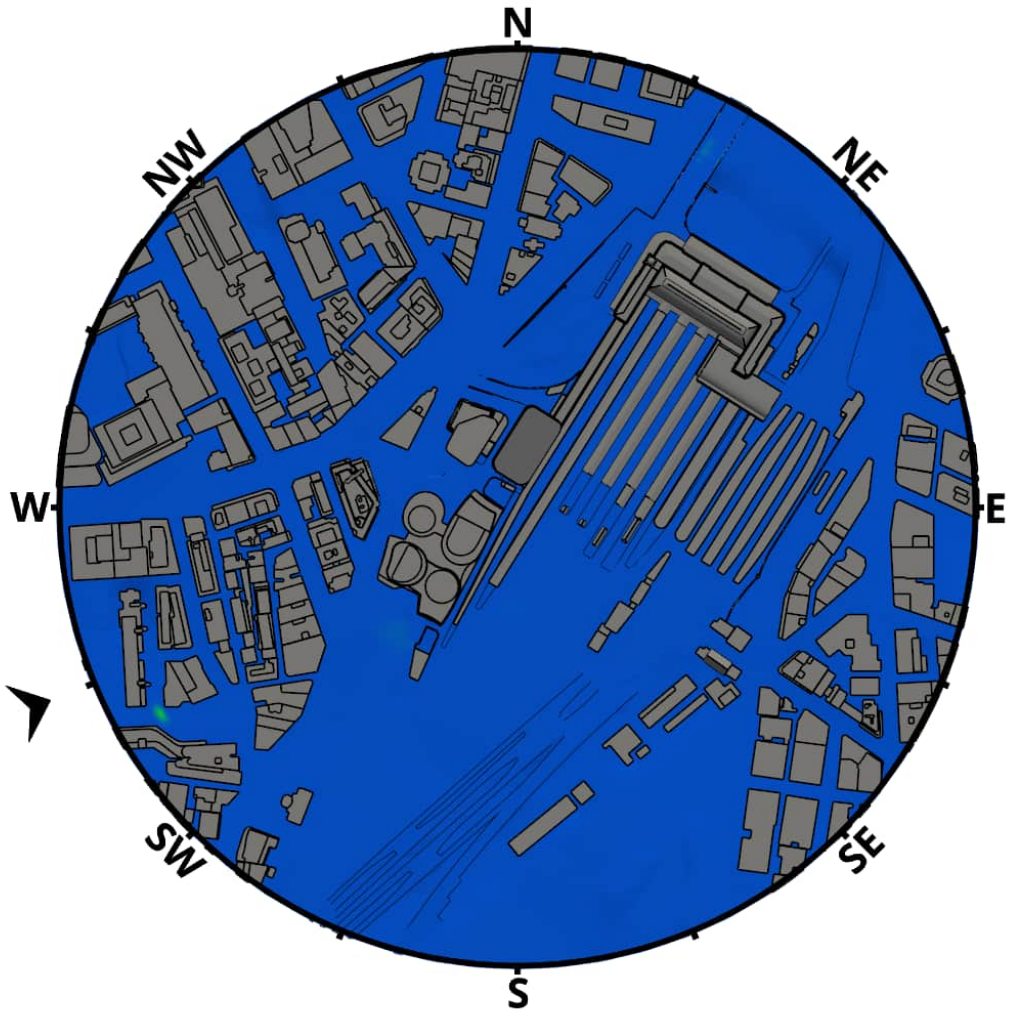

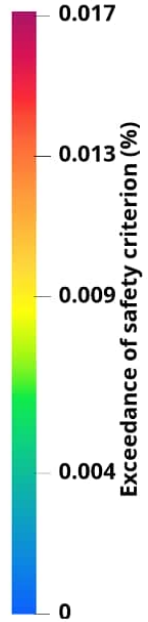

SAFETY CRITERIA - WEST CONTRIBUTION - PLANVIEW - ANNUAL

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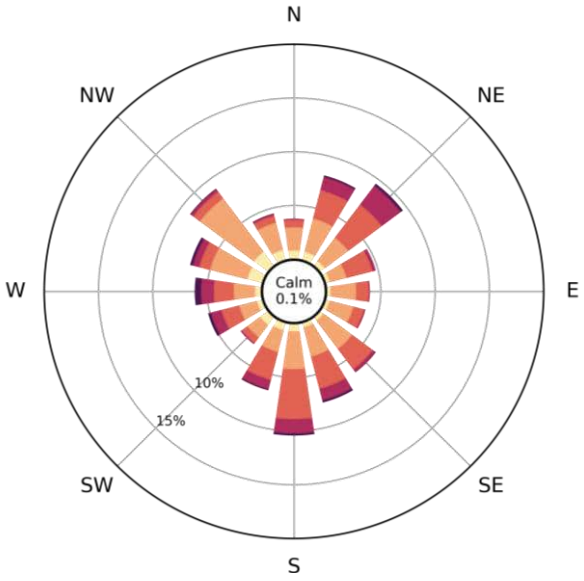

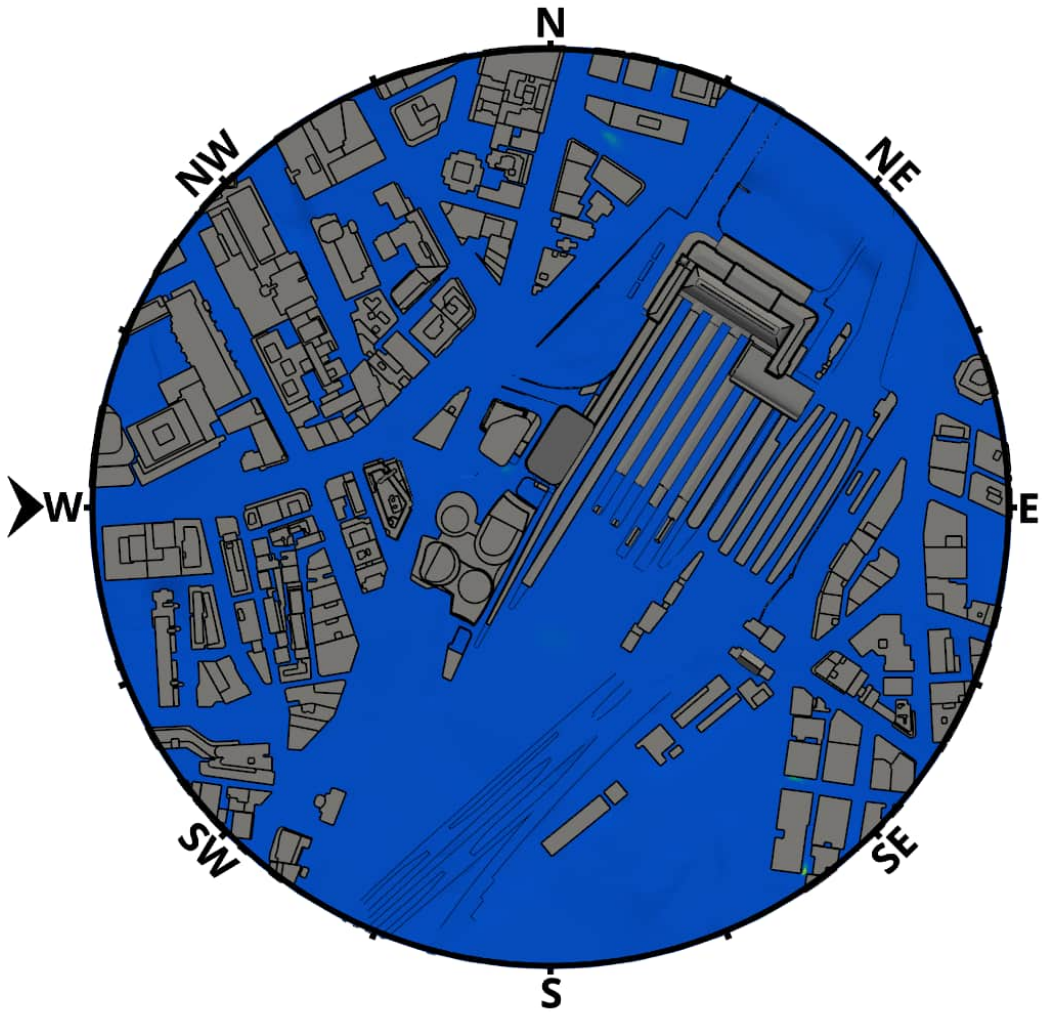

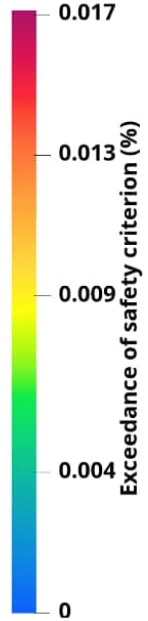

SAFETY CRITERIA - WEST-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

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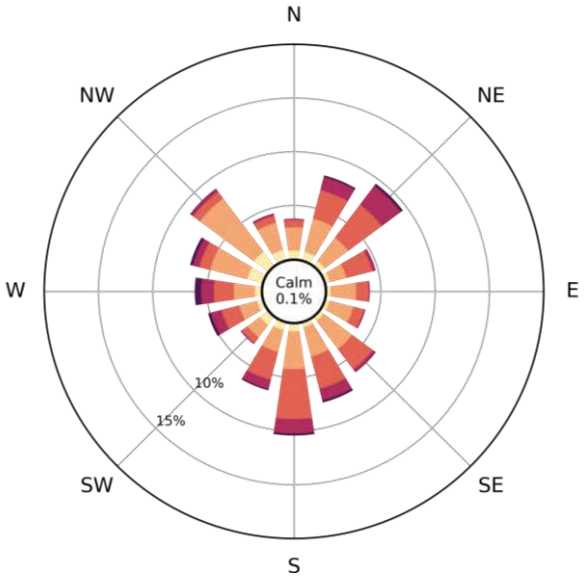

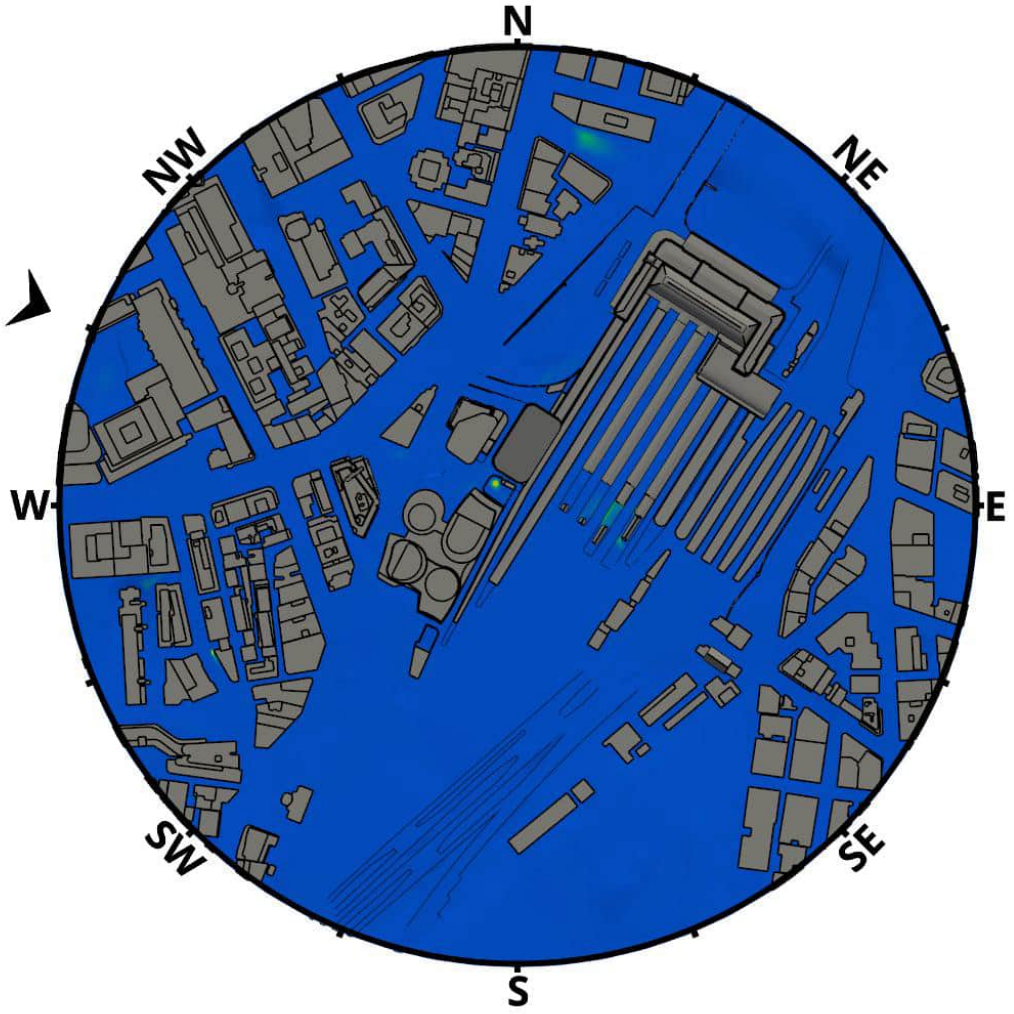

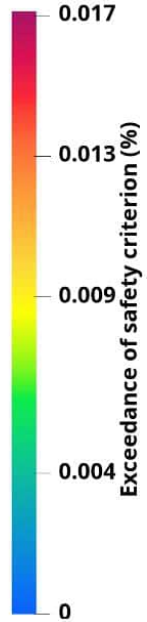

SAFETY CRITERIA - NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

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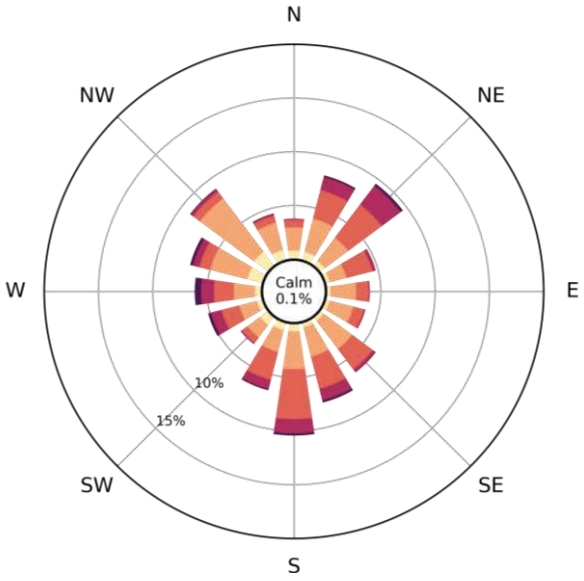

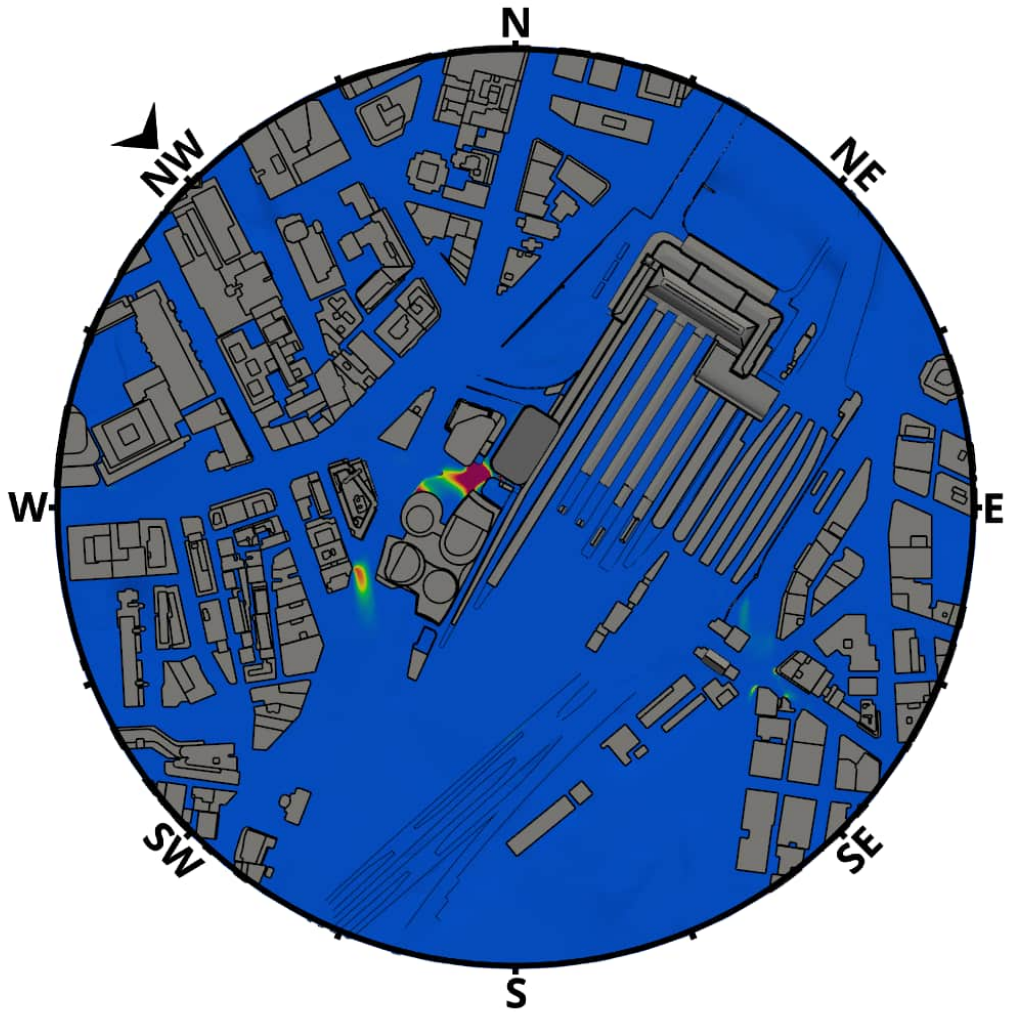

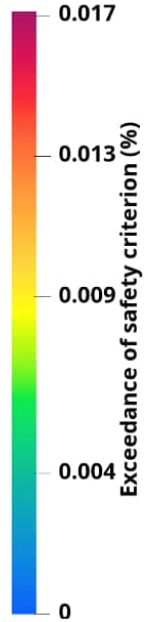

SAFETY CRITERIA - NORTH-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

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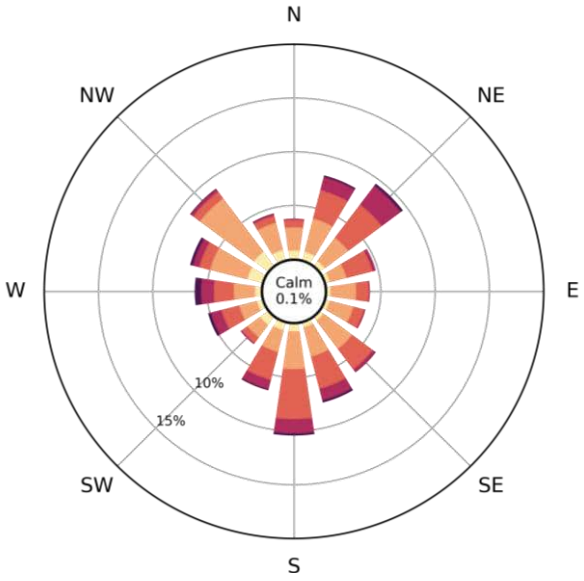
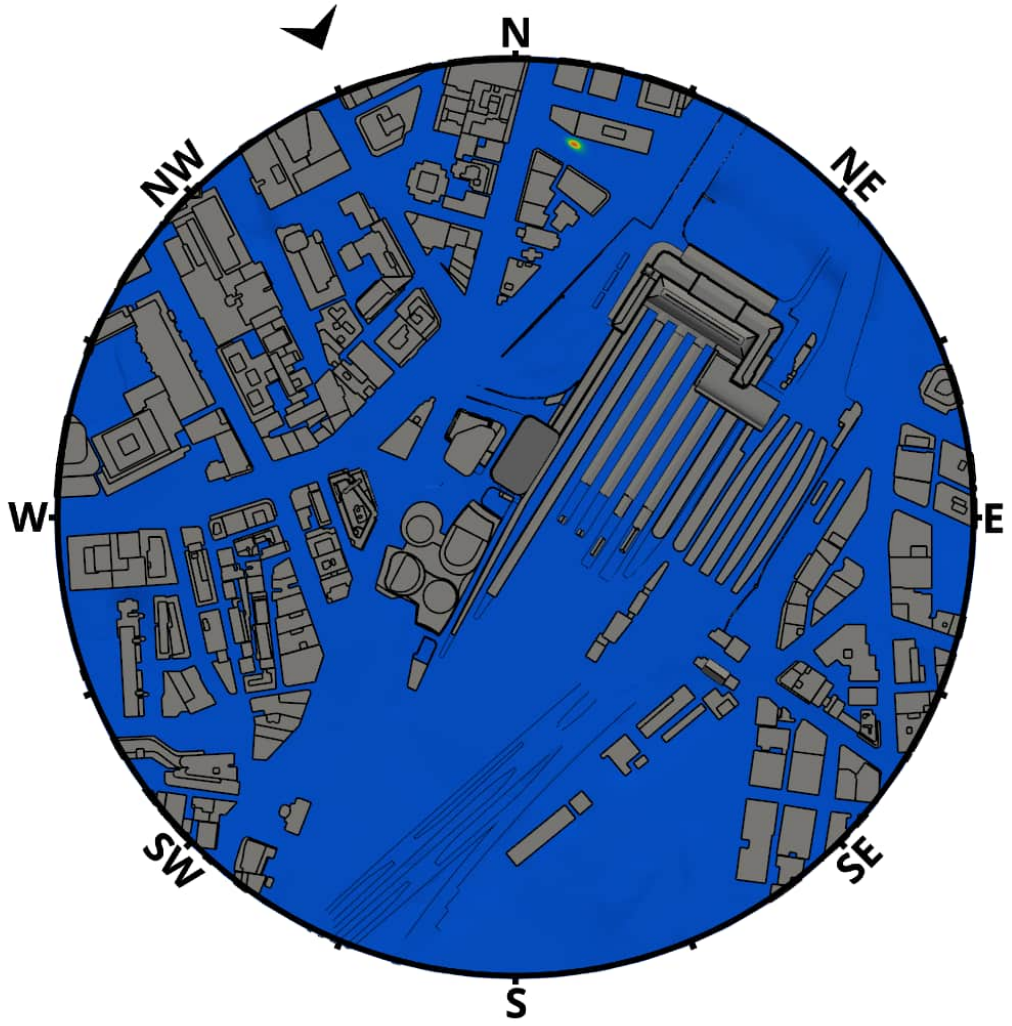
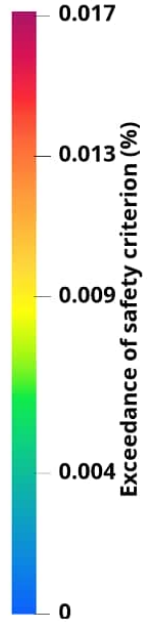


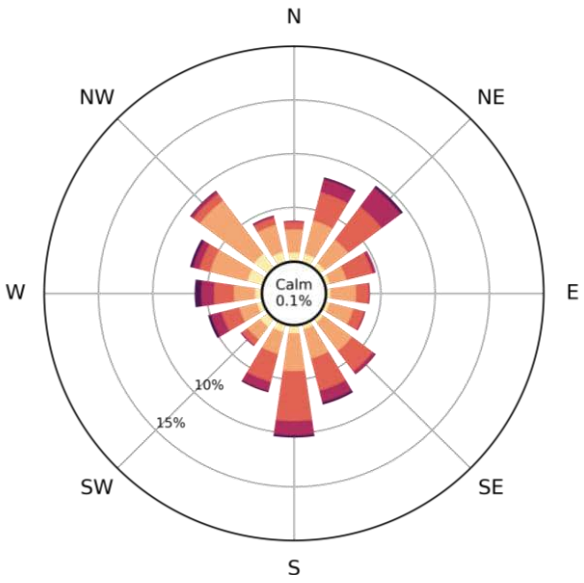


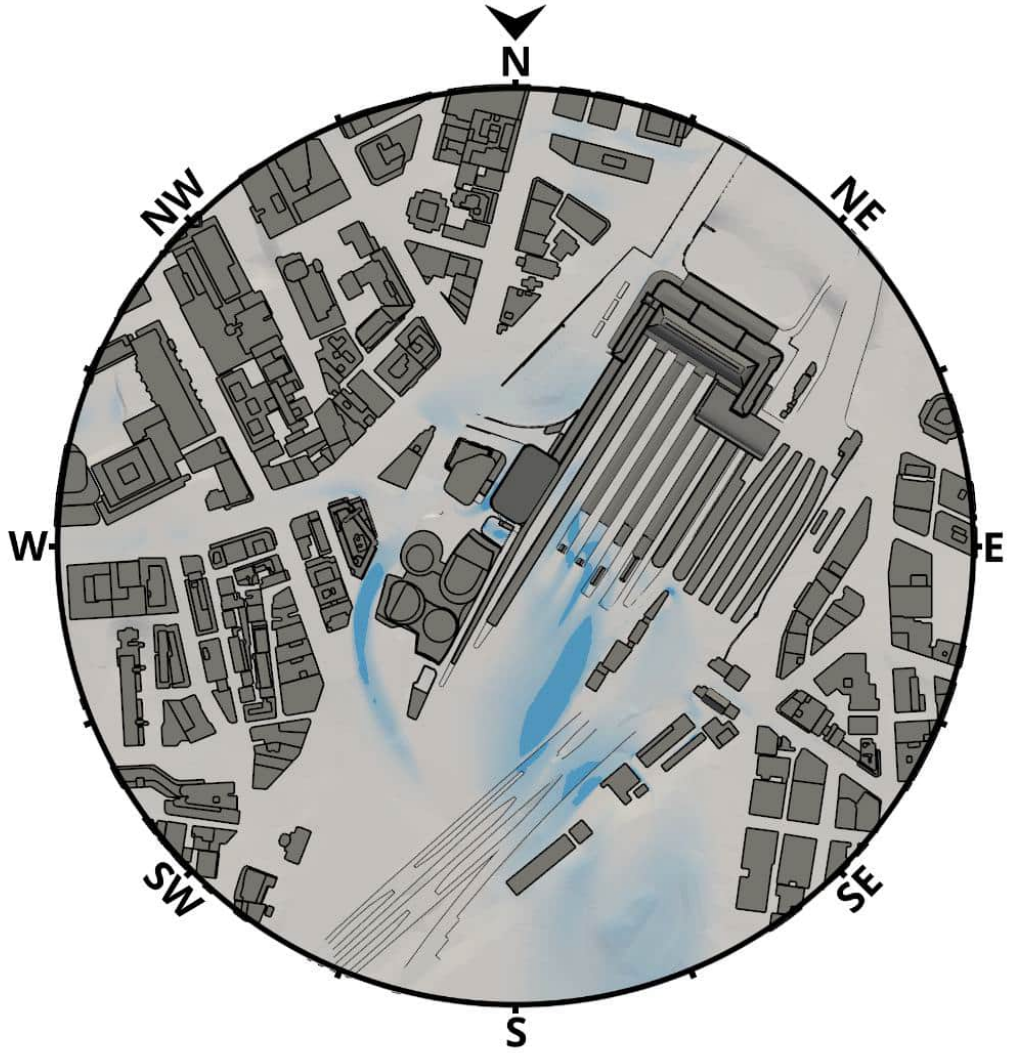


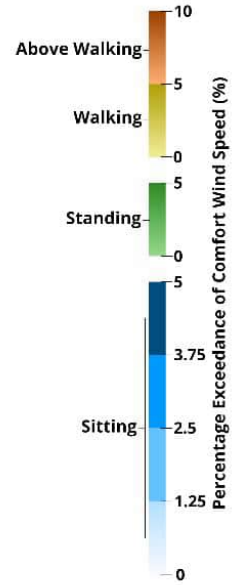
Existing - Directional Contributions - Comfort

COMFORT CRITERIA - NORTH CONTRIBUTION - PLANVIEW - ANNUAL

Existing







COMFORT CRITERIA - NORTH-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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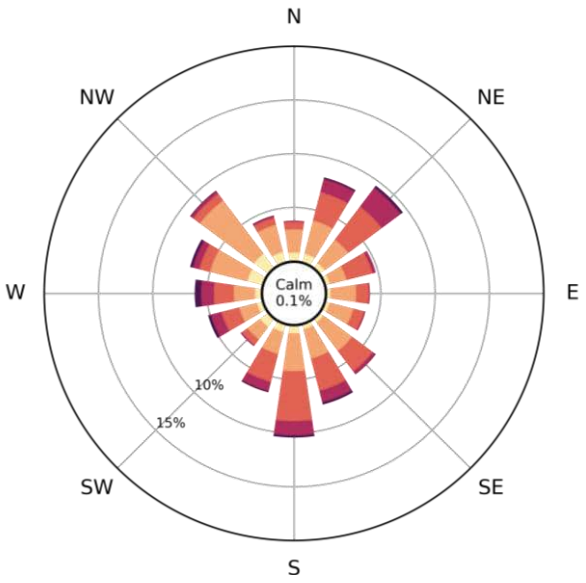

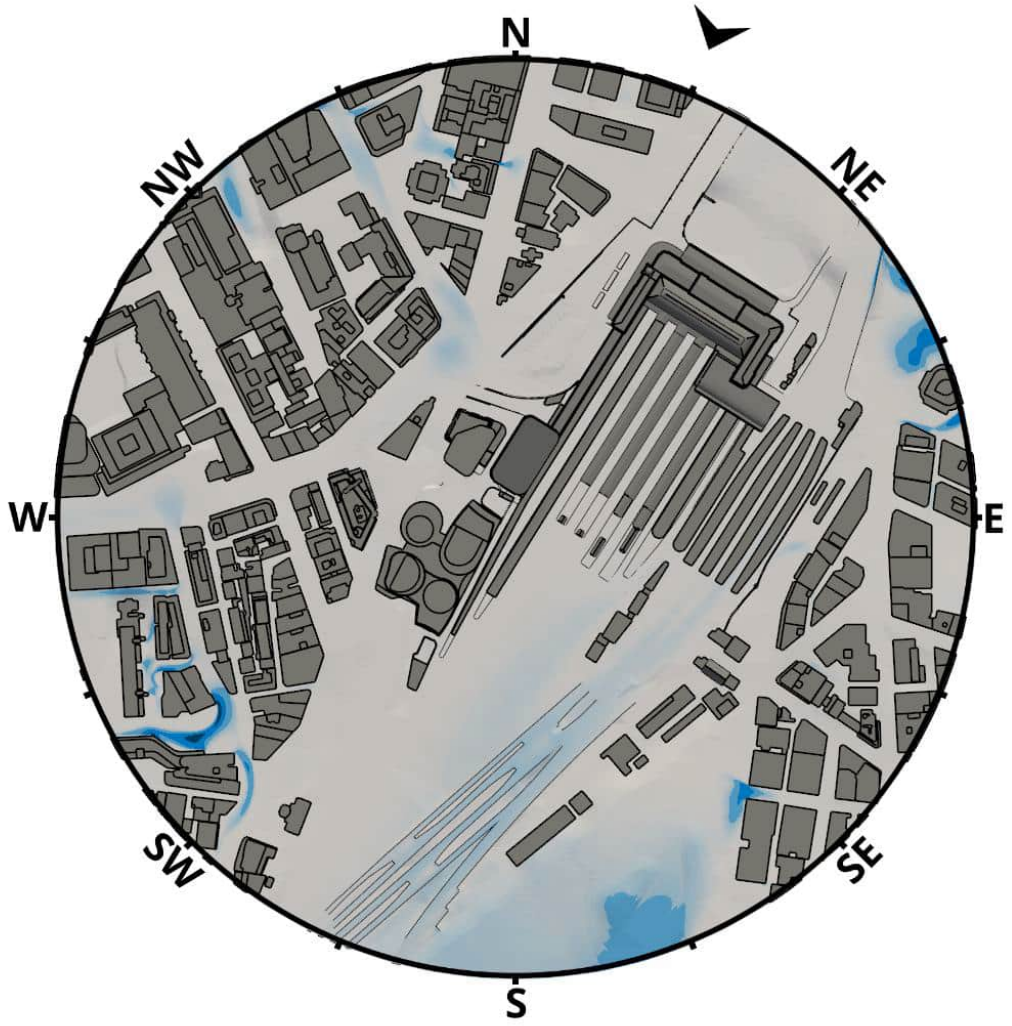

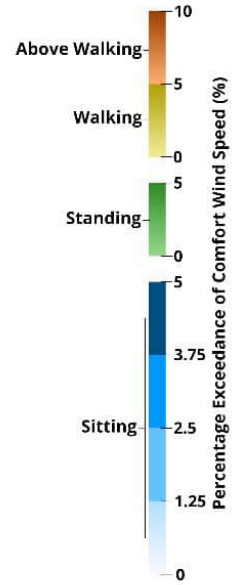

COMFORT CRITERIA - NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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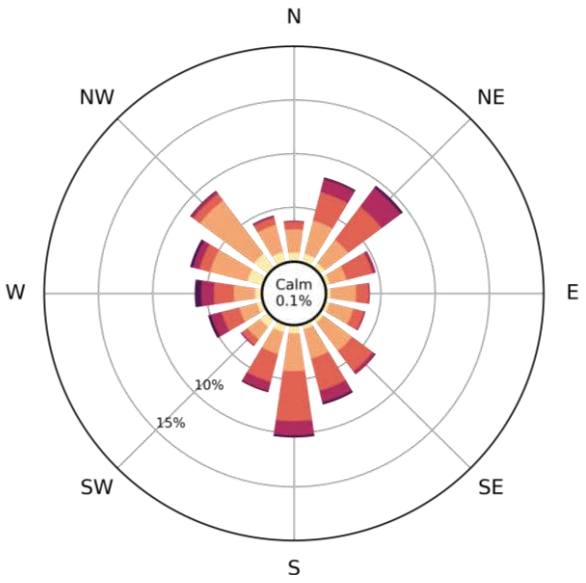

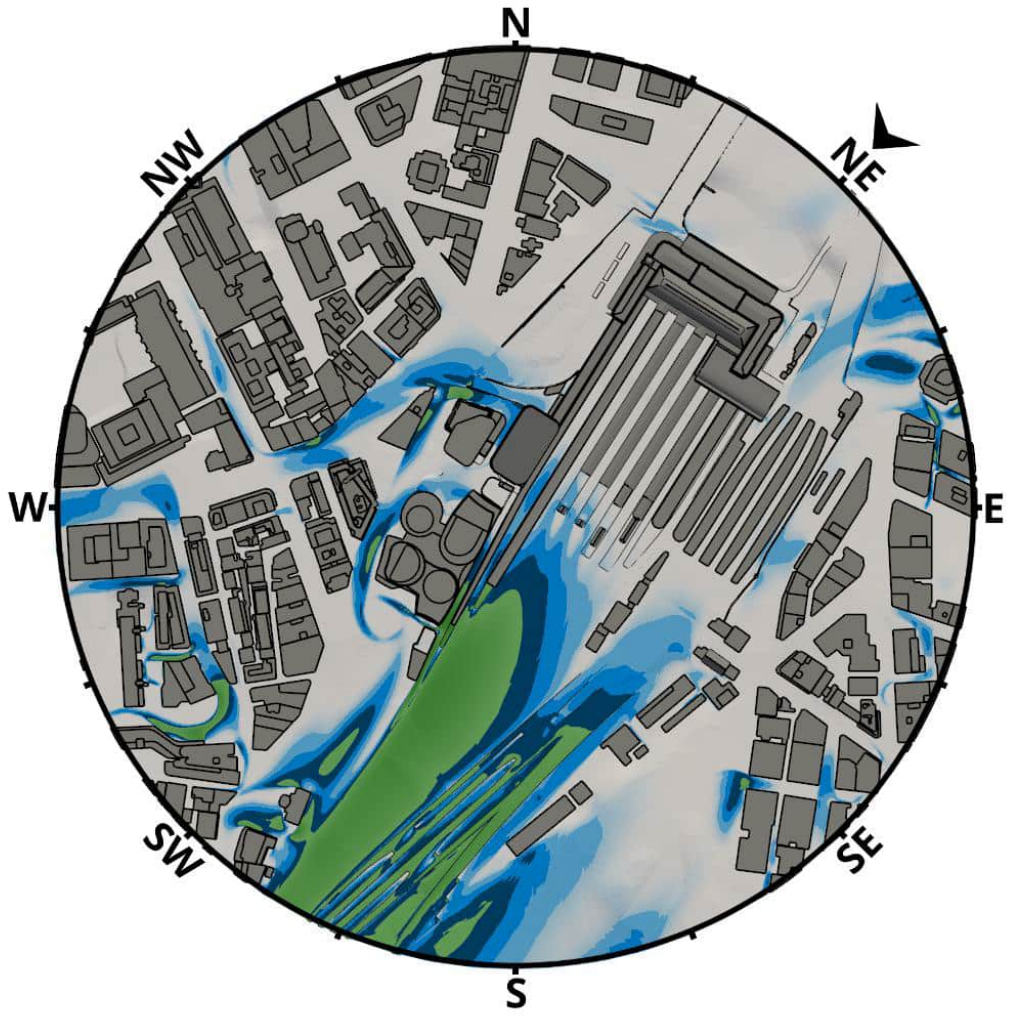

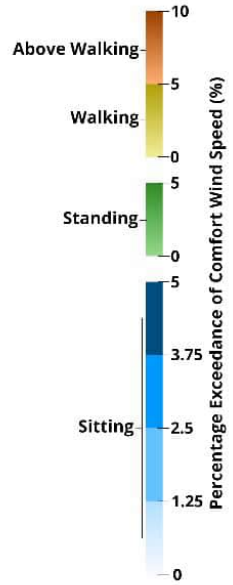

COMFORT CRITERIA - EAST-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

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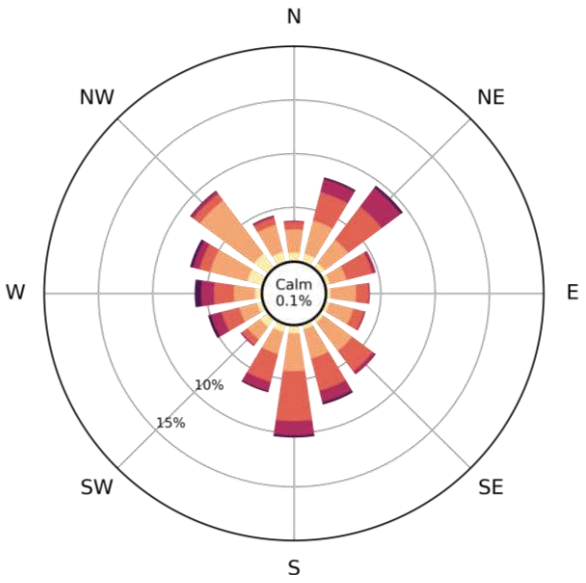
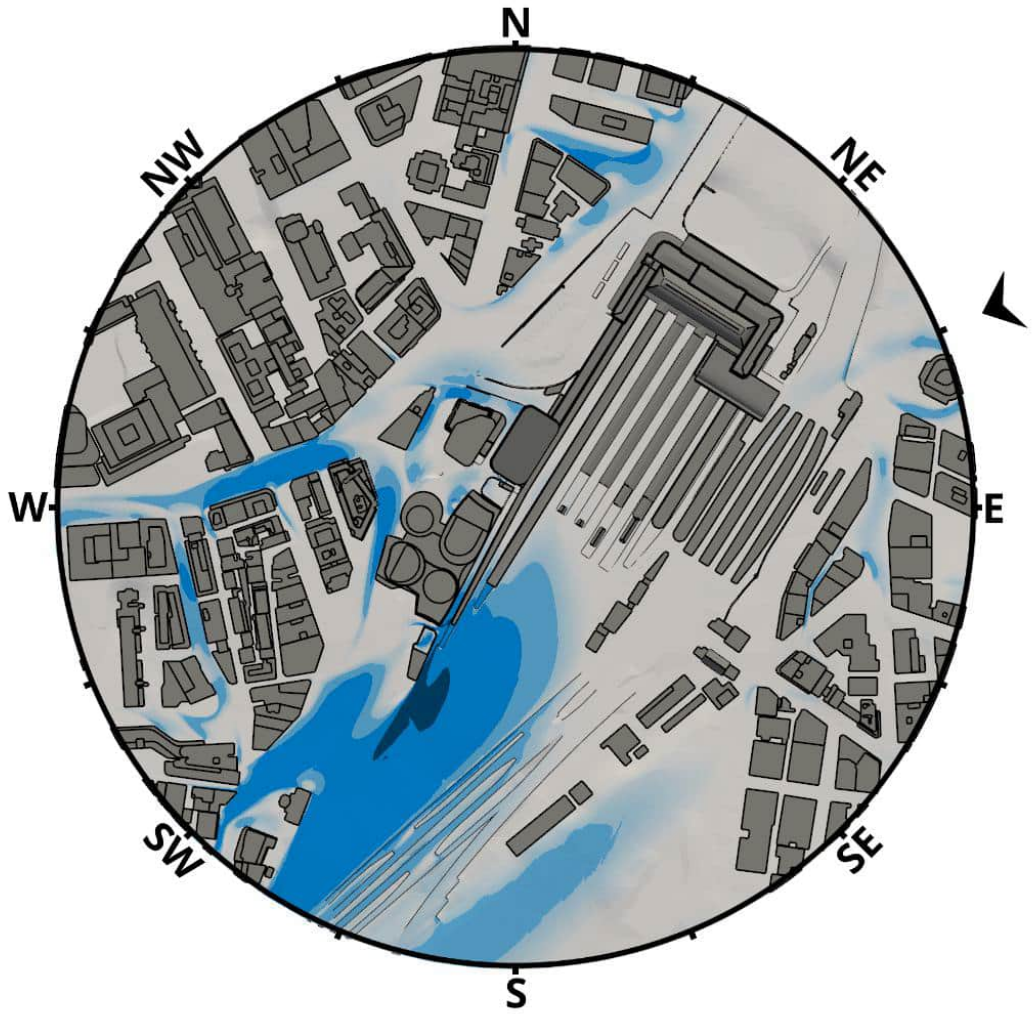
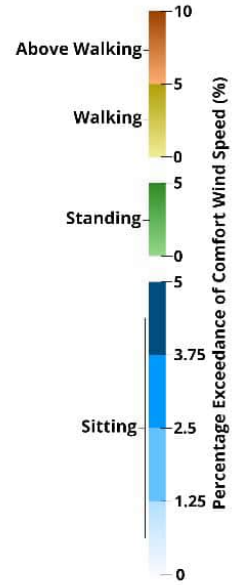
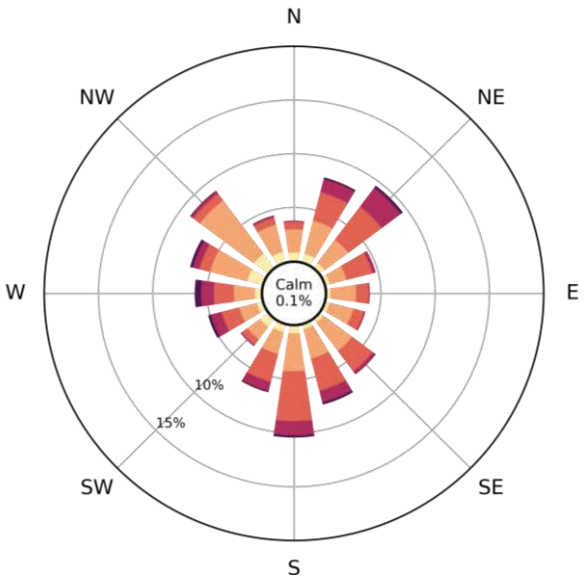


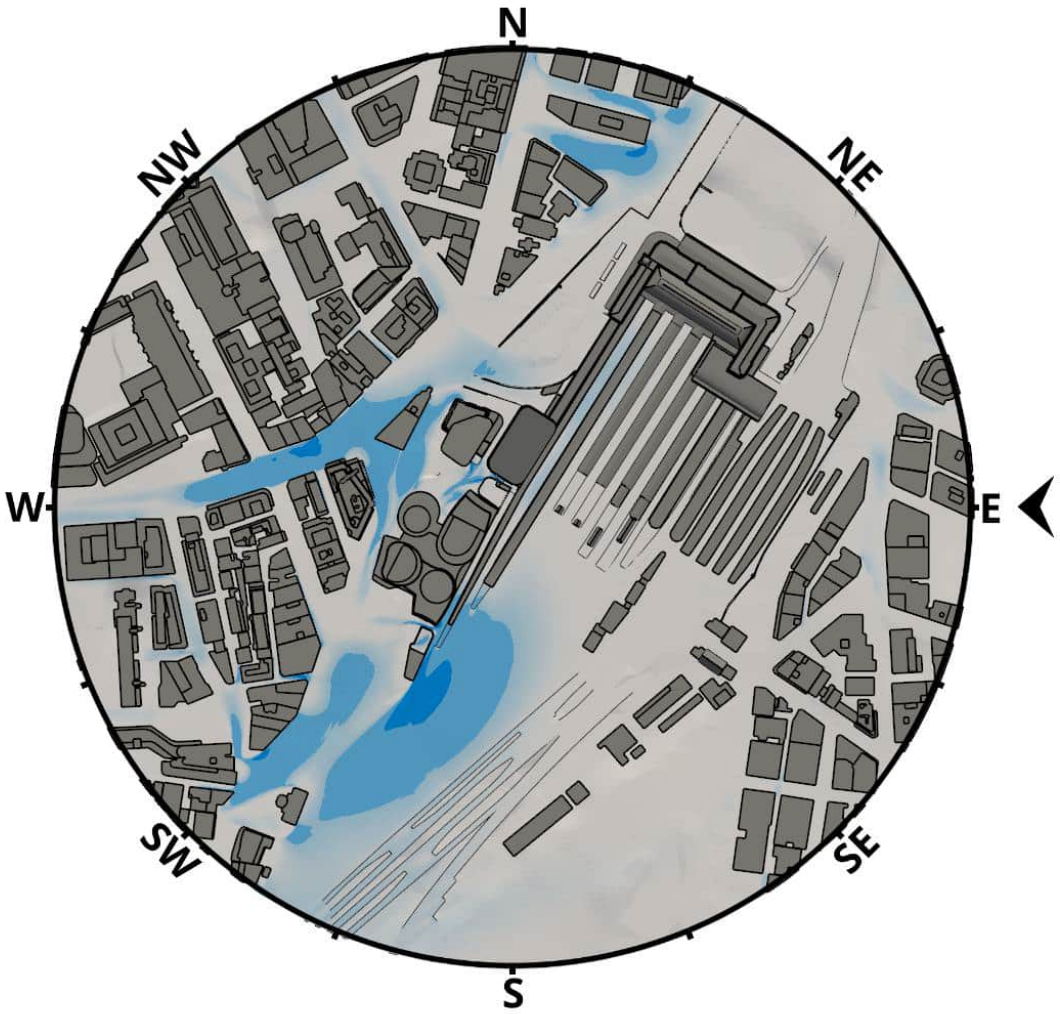


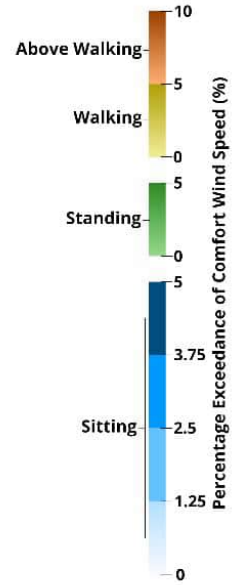


COMFORT CRITERIA - EAST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

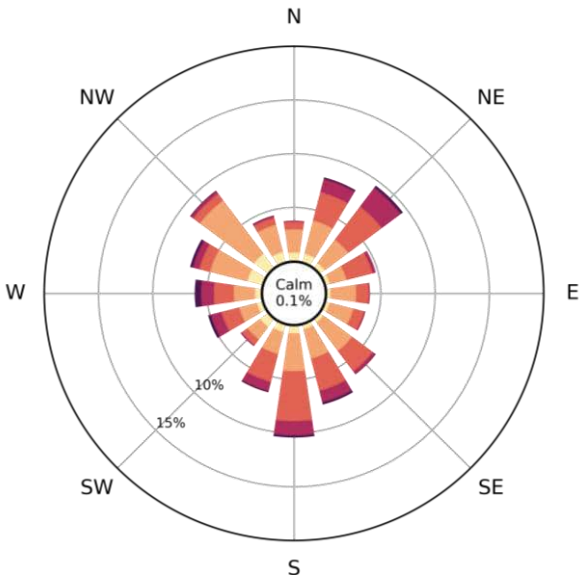


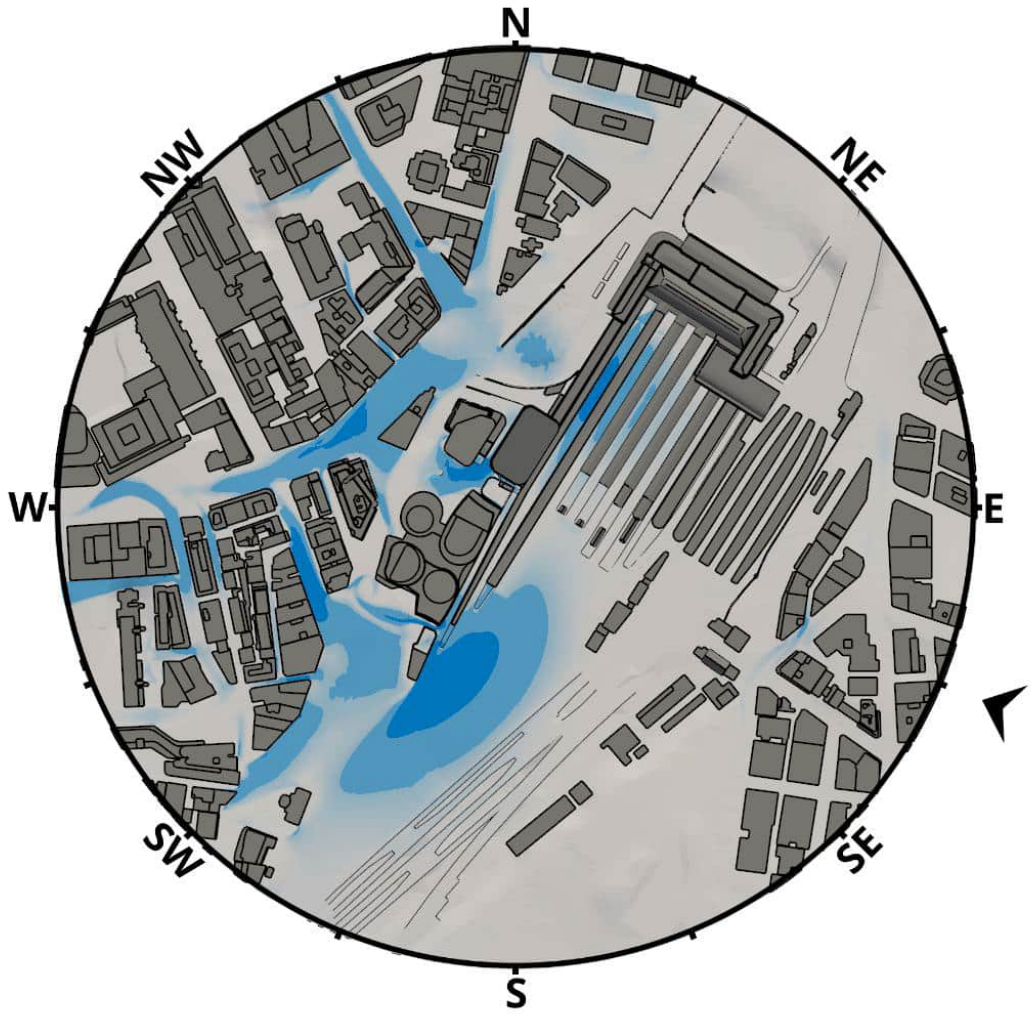


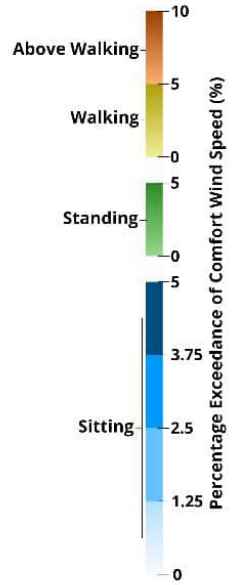


COMFORT CRITERIA - EAST-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

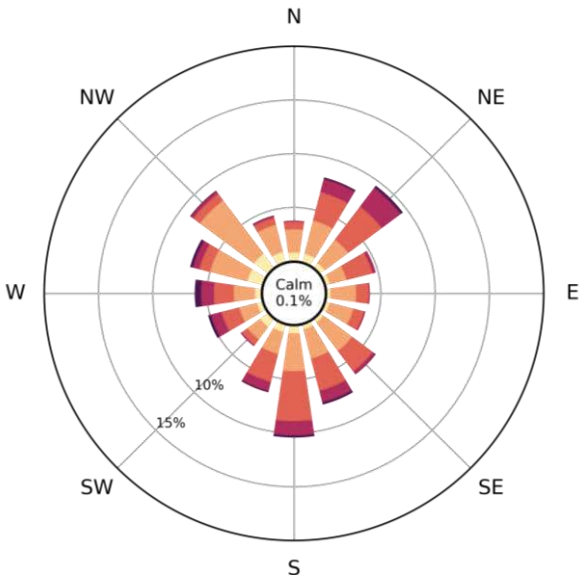


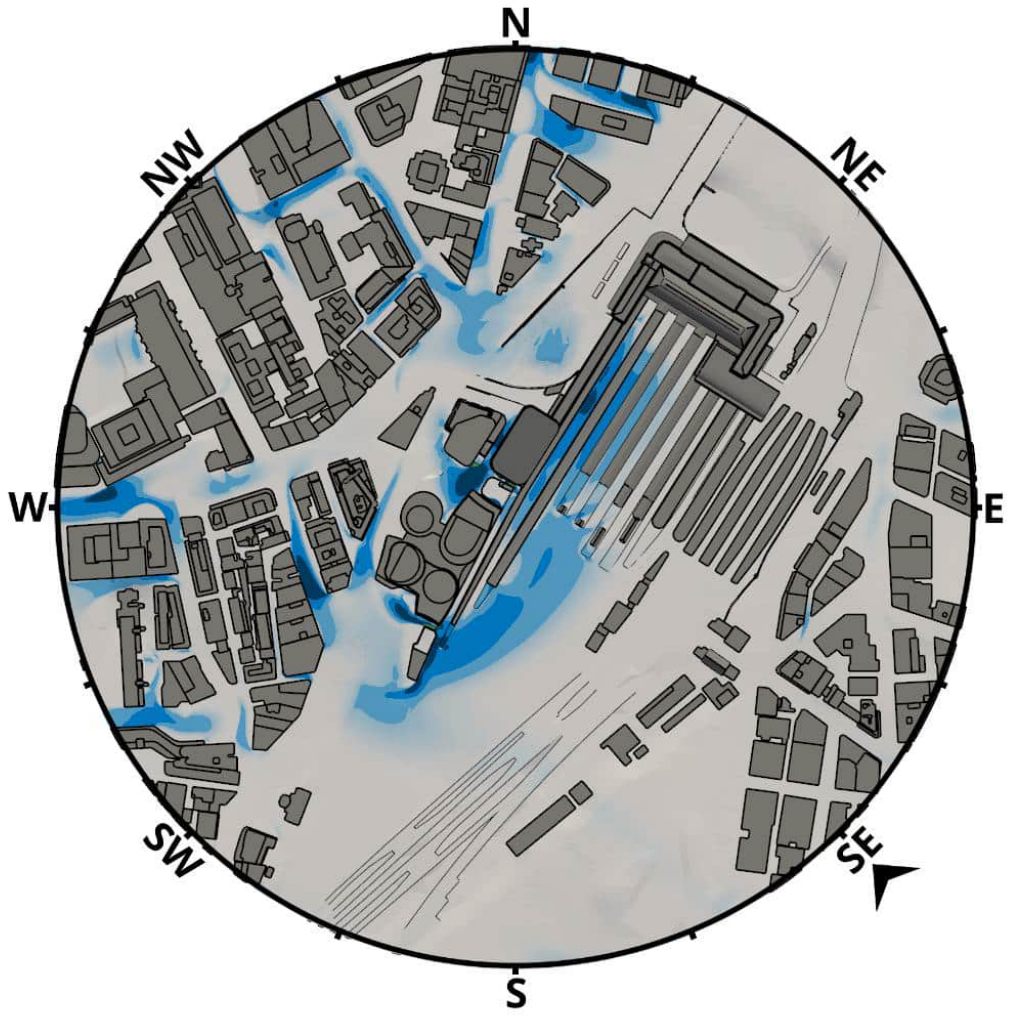


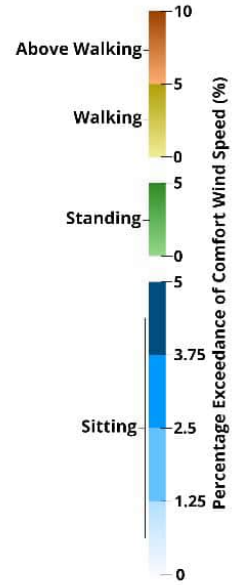


COMFORT CRITERIA - SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

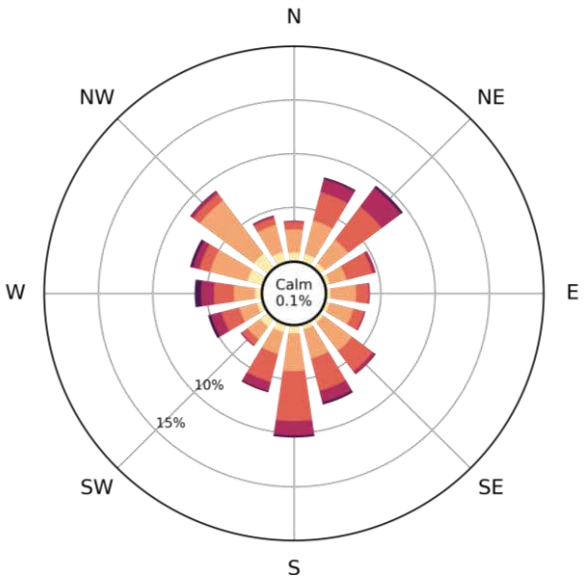


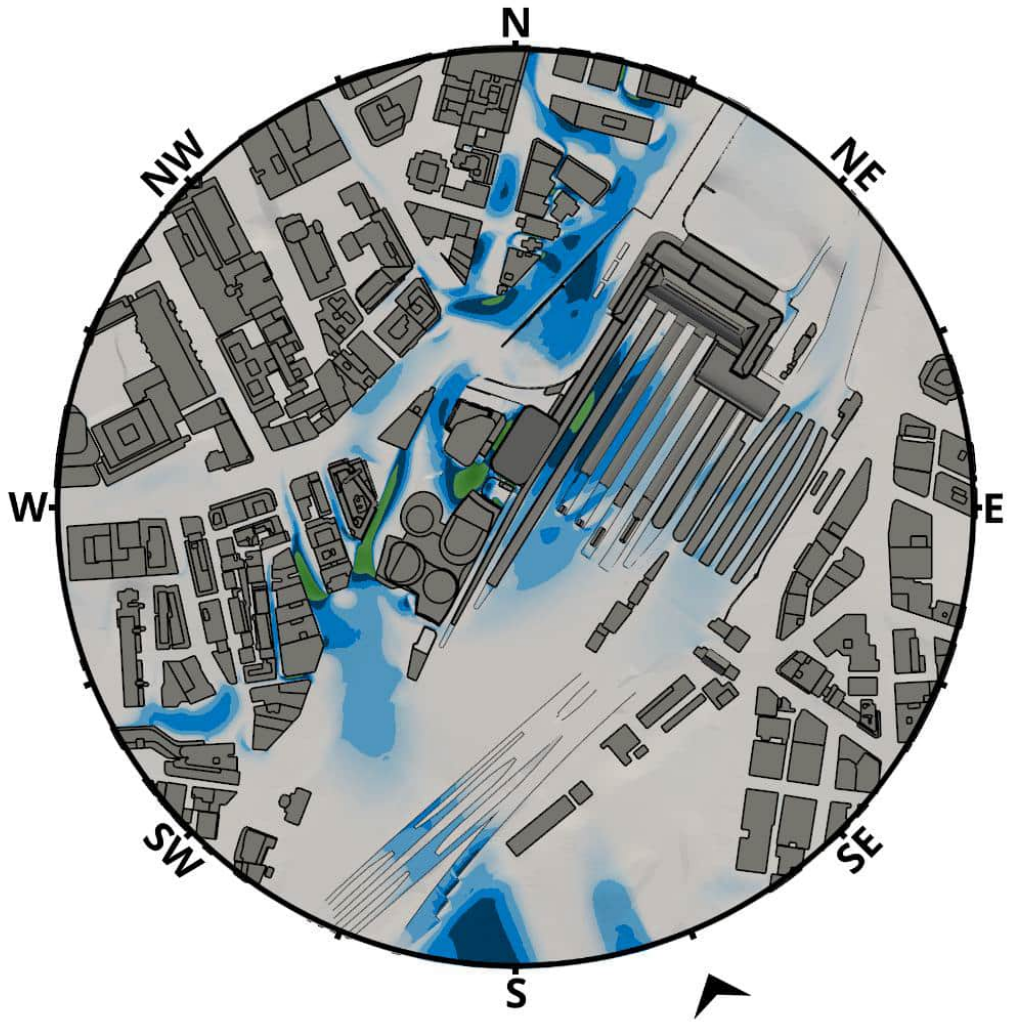


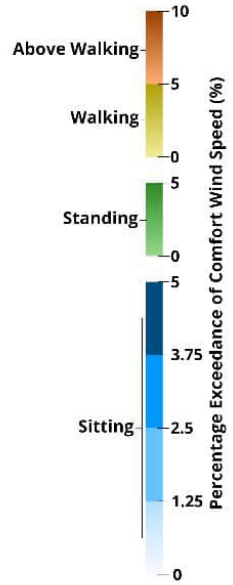


COMFORT CRITERIA - SOUTH-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

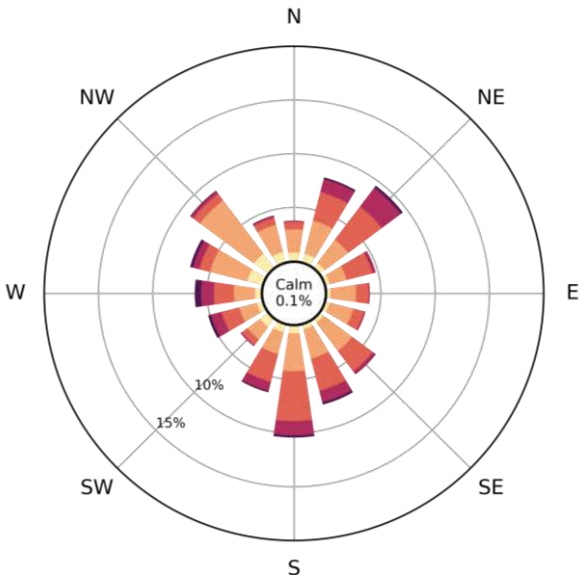


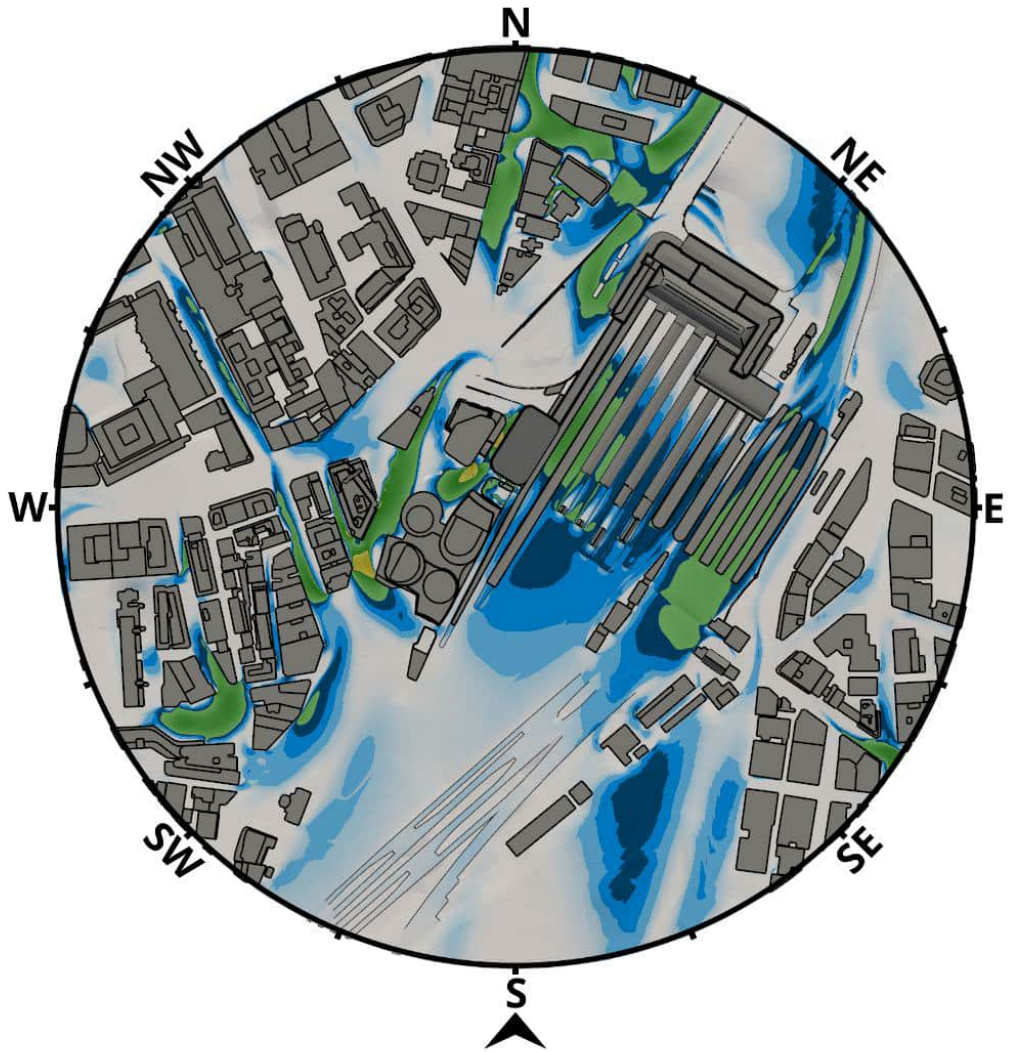


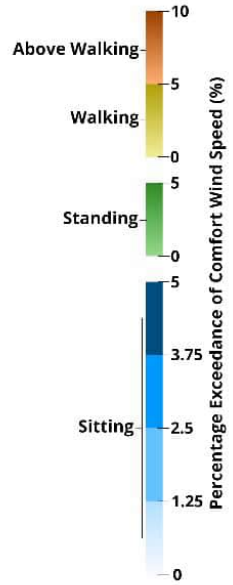


COMFORT CRITERIA - SOUTH CONTRIBUTION - PLANVIEW - ANNUAL

Existing

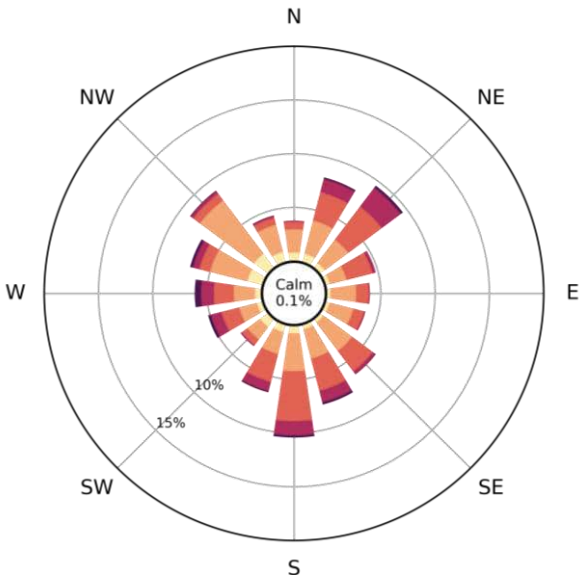


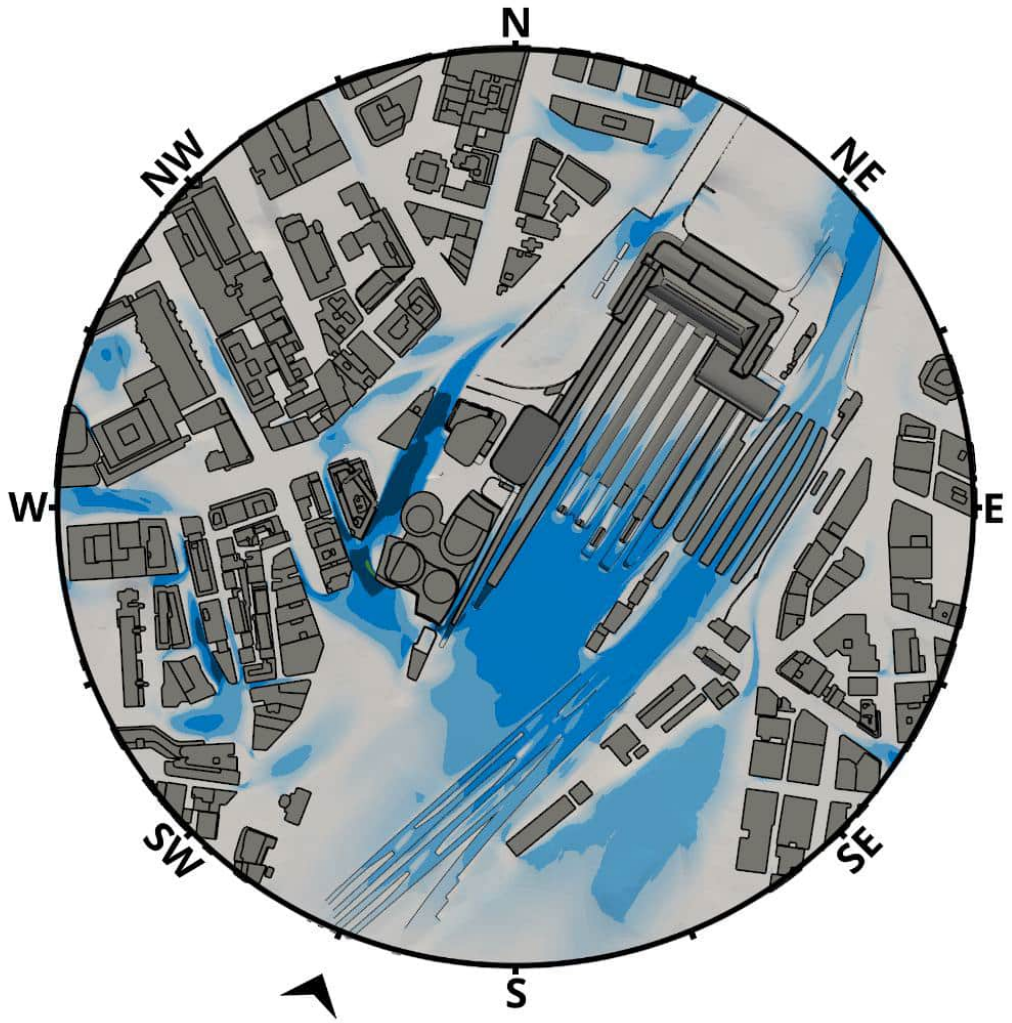


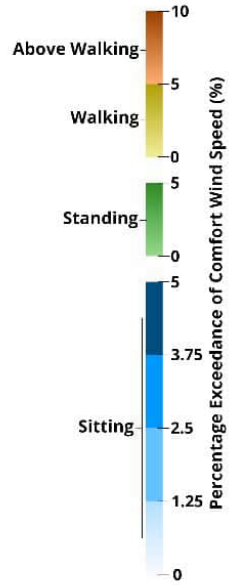


COMFORT CRITERIA - SOUTH-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

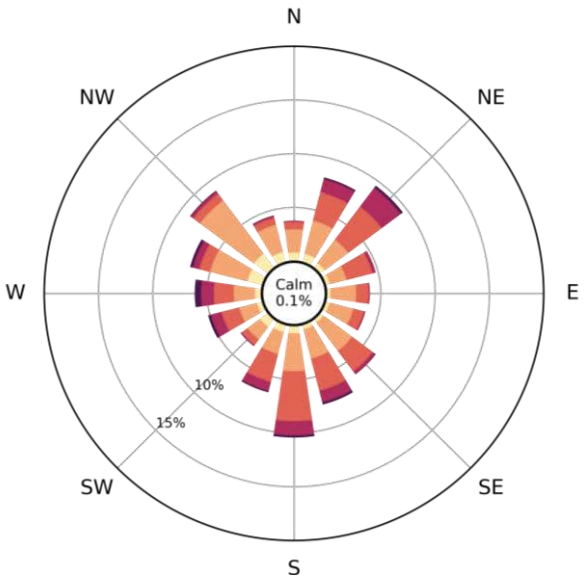


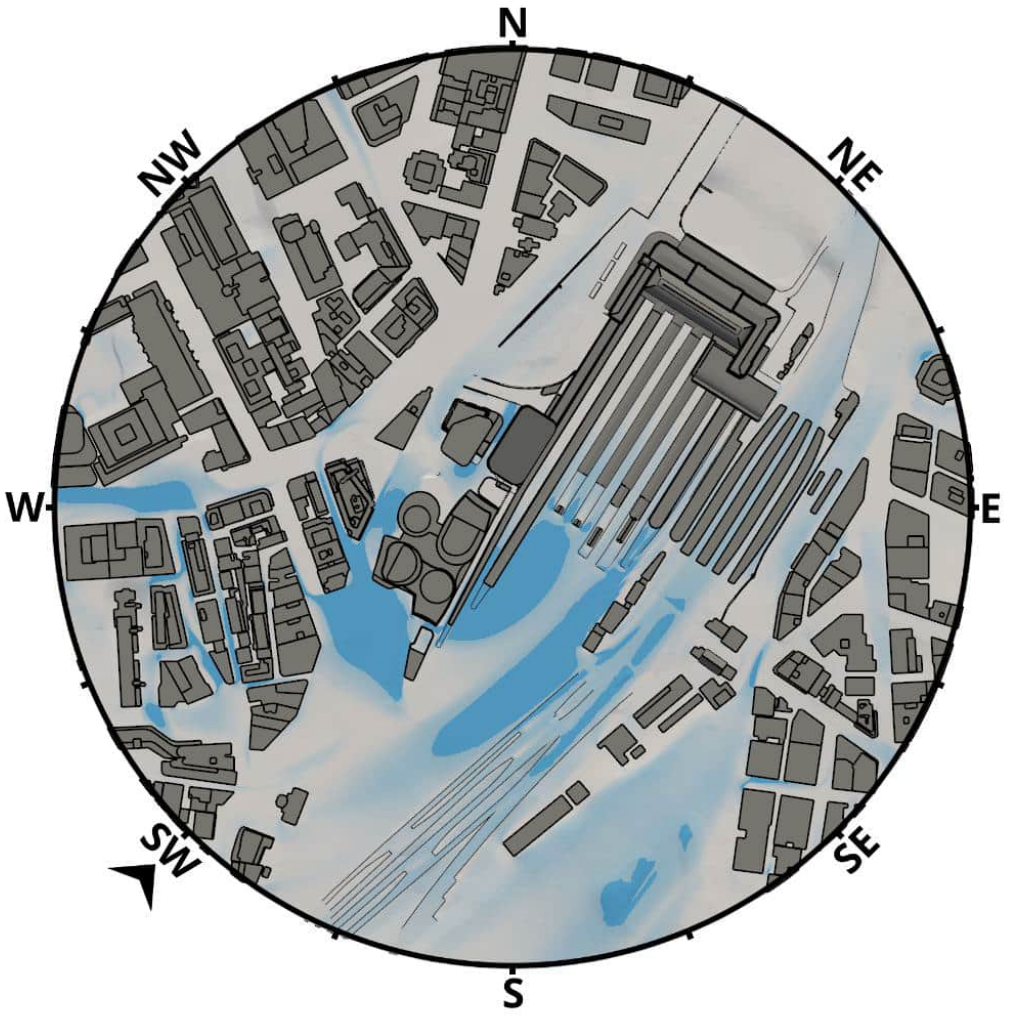


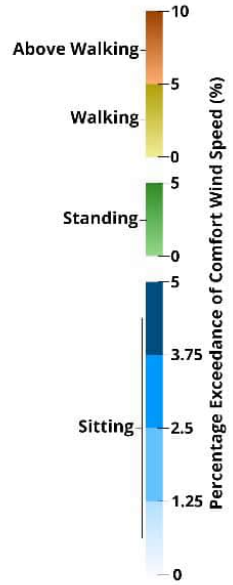


COMFORT CRITERIA - SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

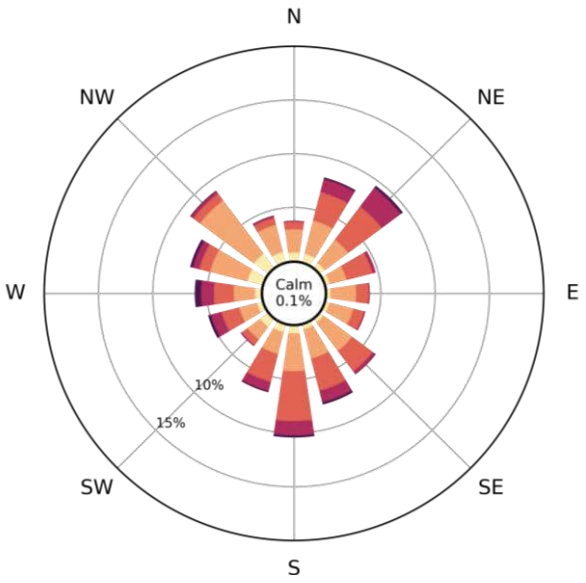


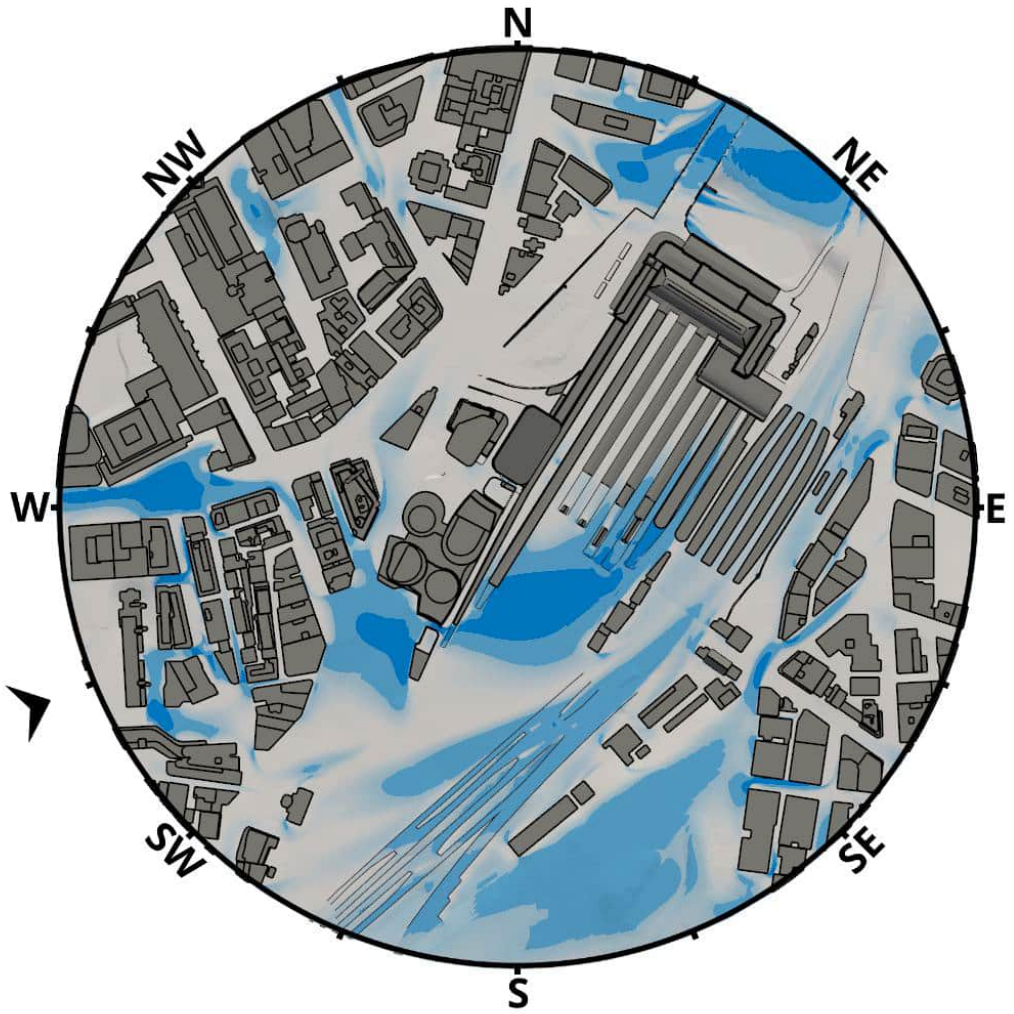


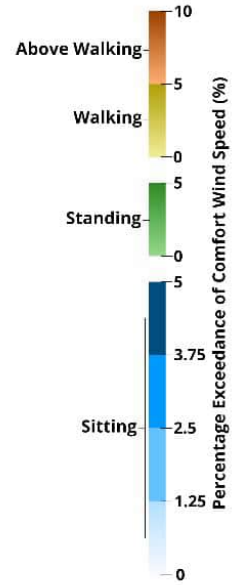


COMFORT CRITERIA - WEST-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

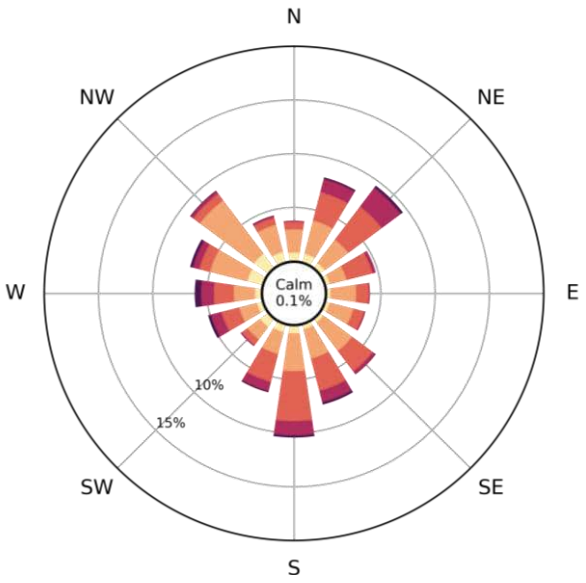


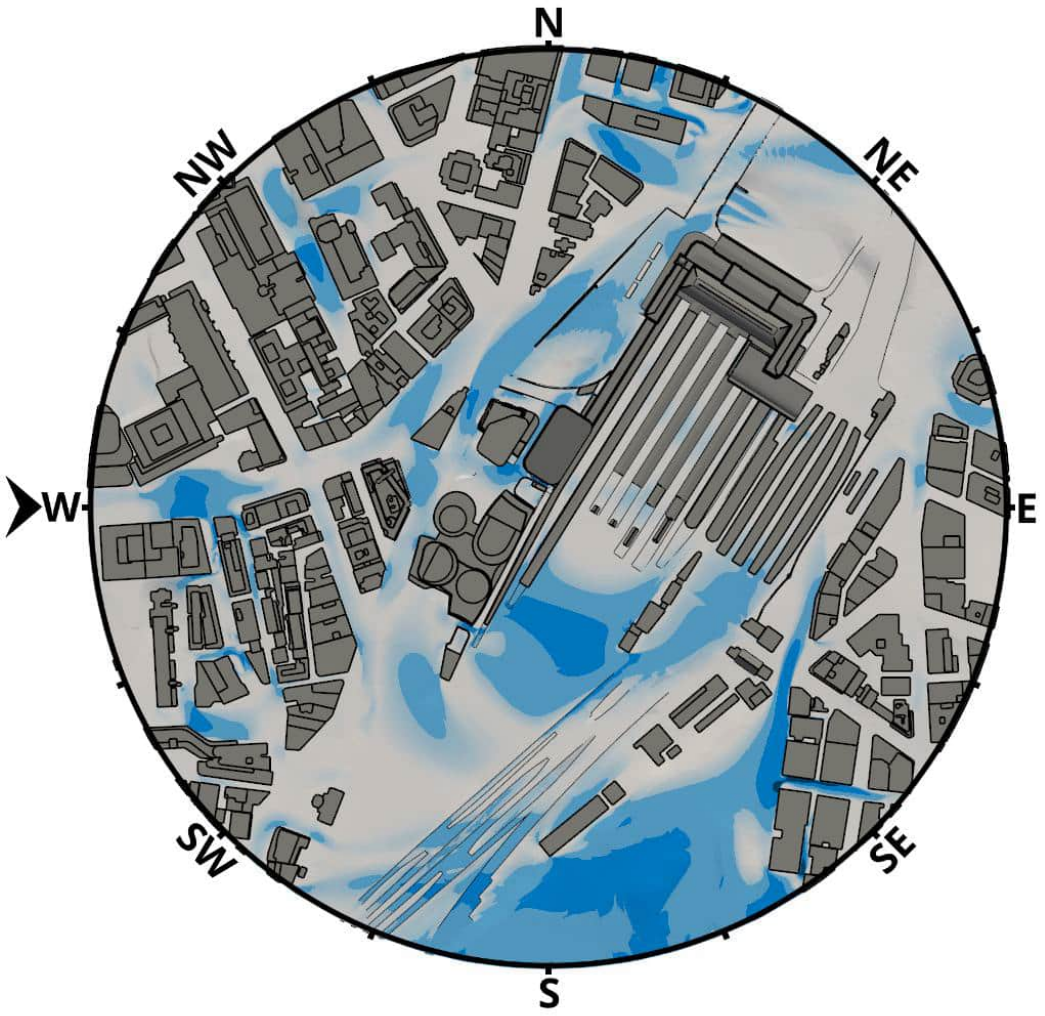


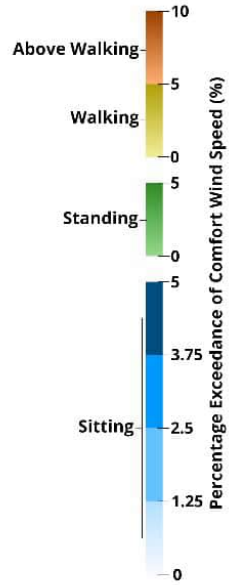


COMFORT CRITERIA - WEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

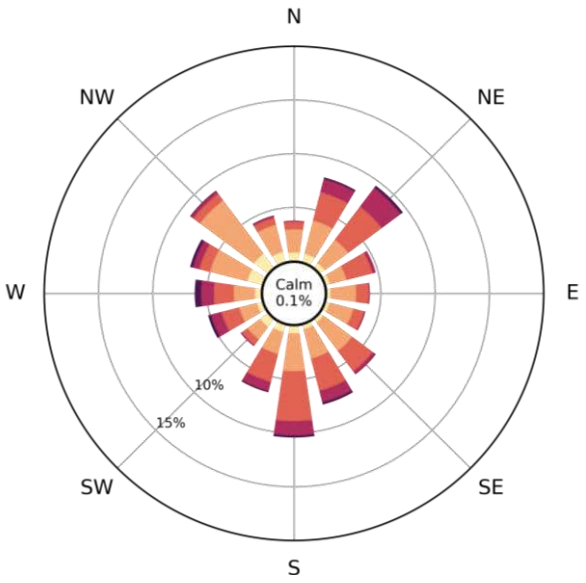


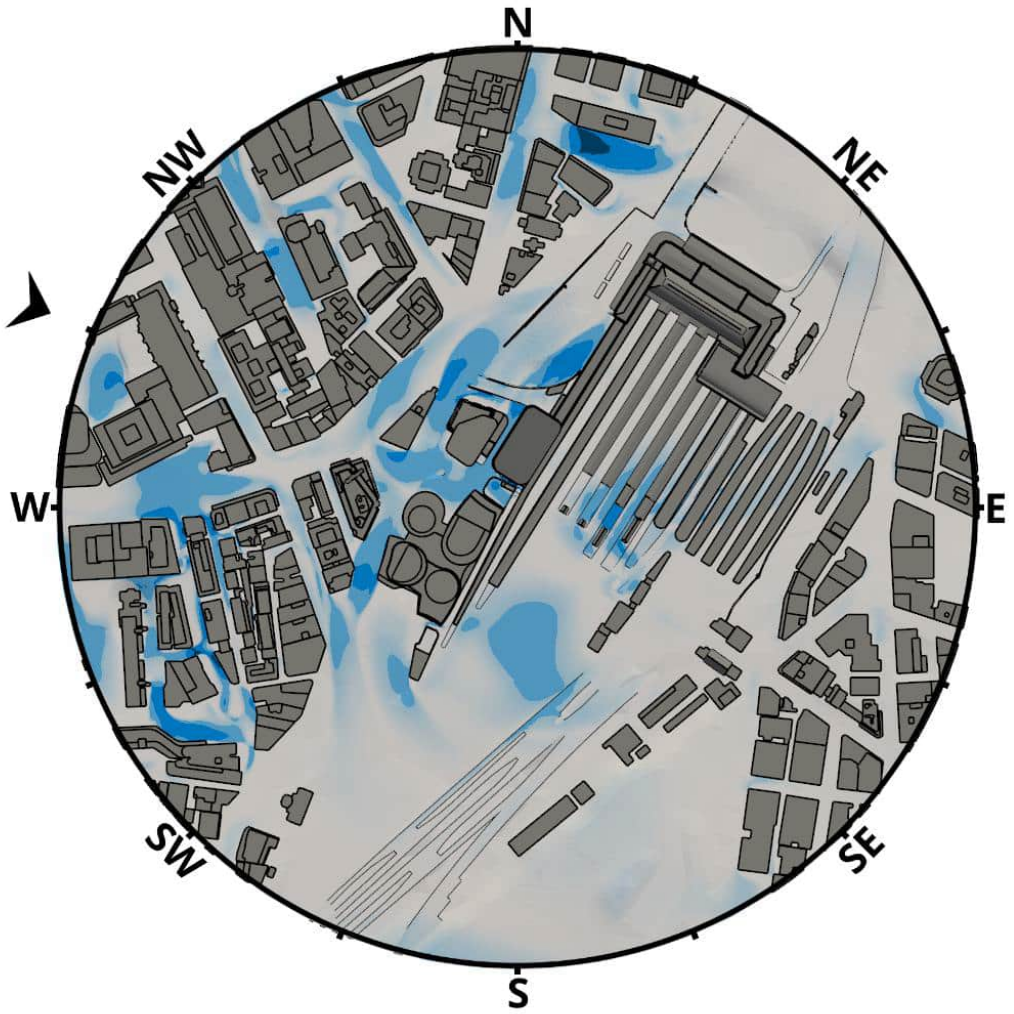


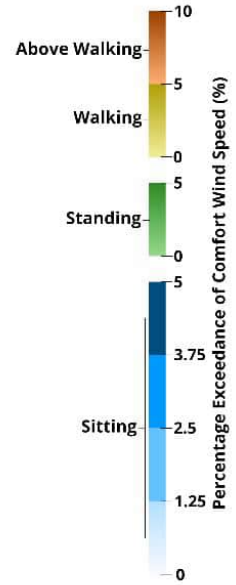


COMFORT CRITERIA - WEST-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

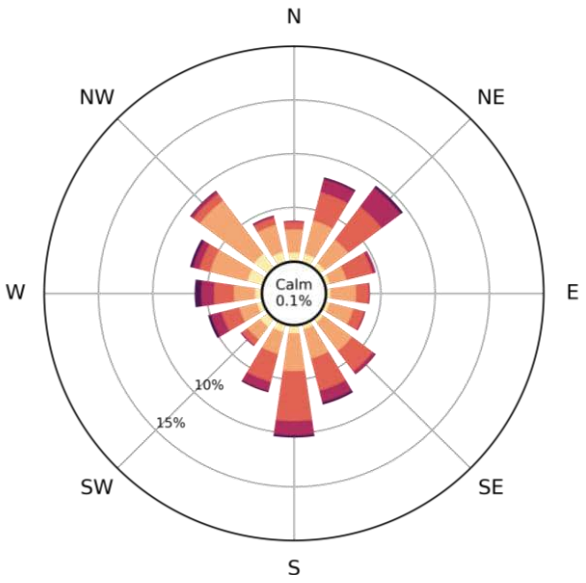


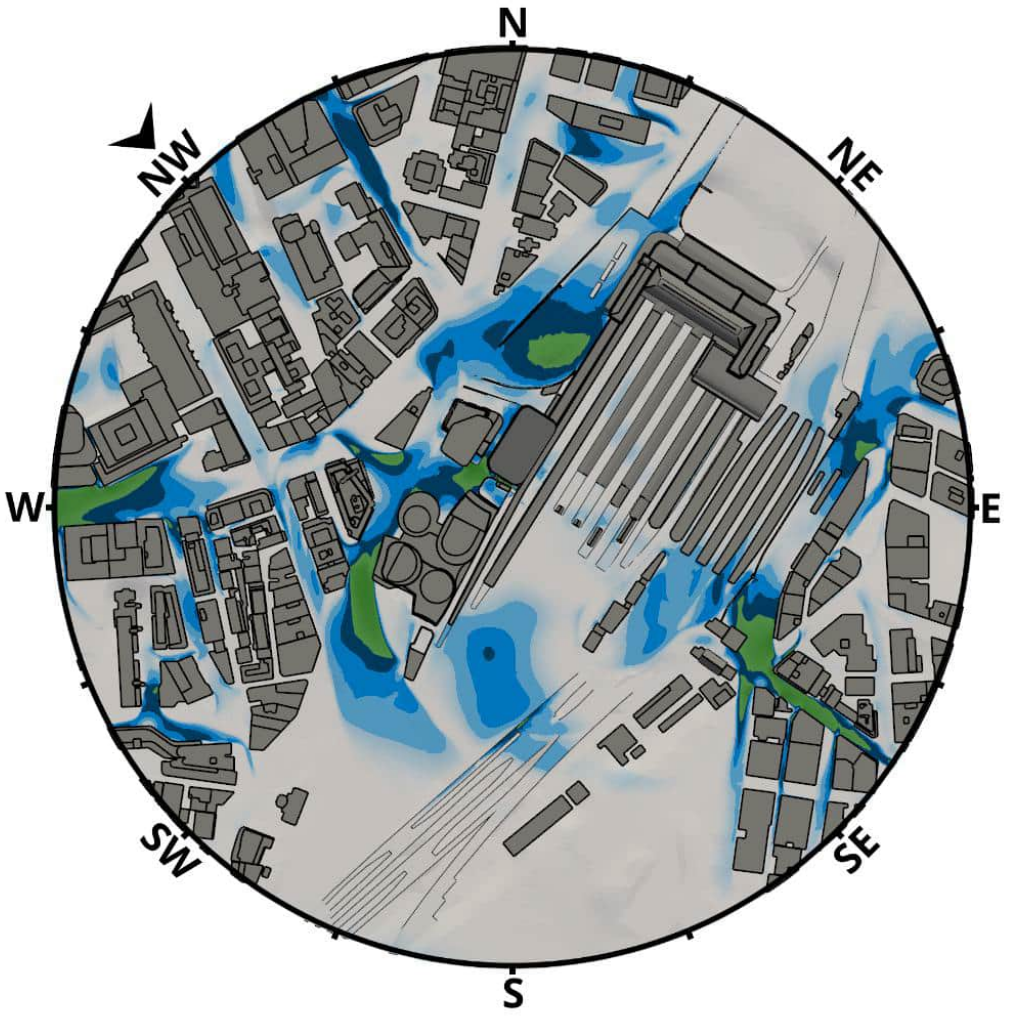


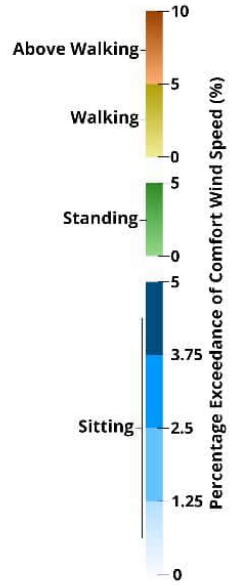


COMFORT CRITERIA - NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing

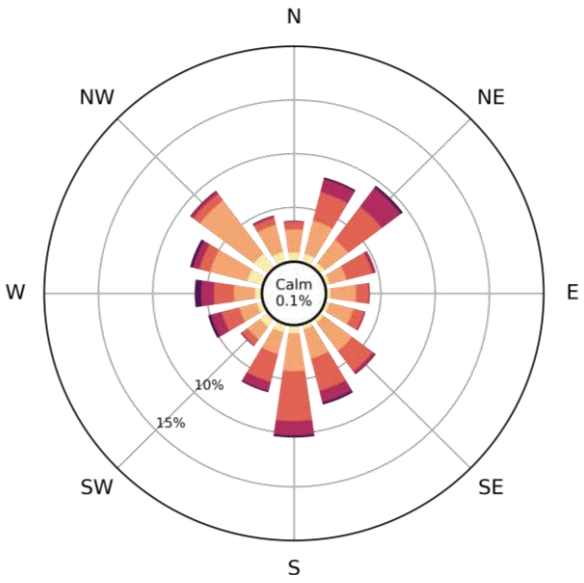


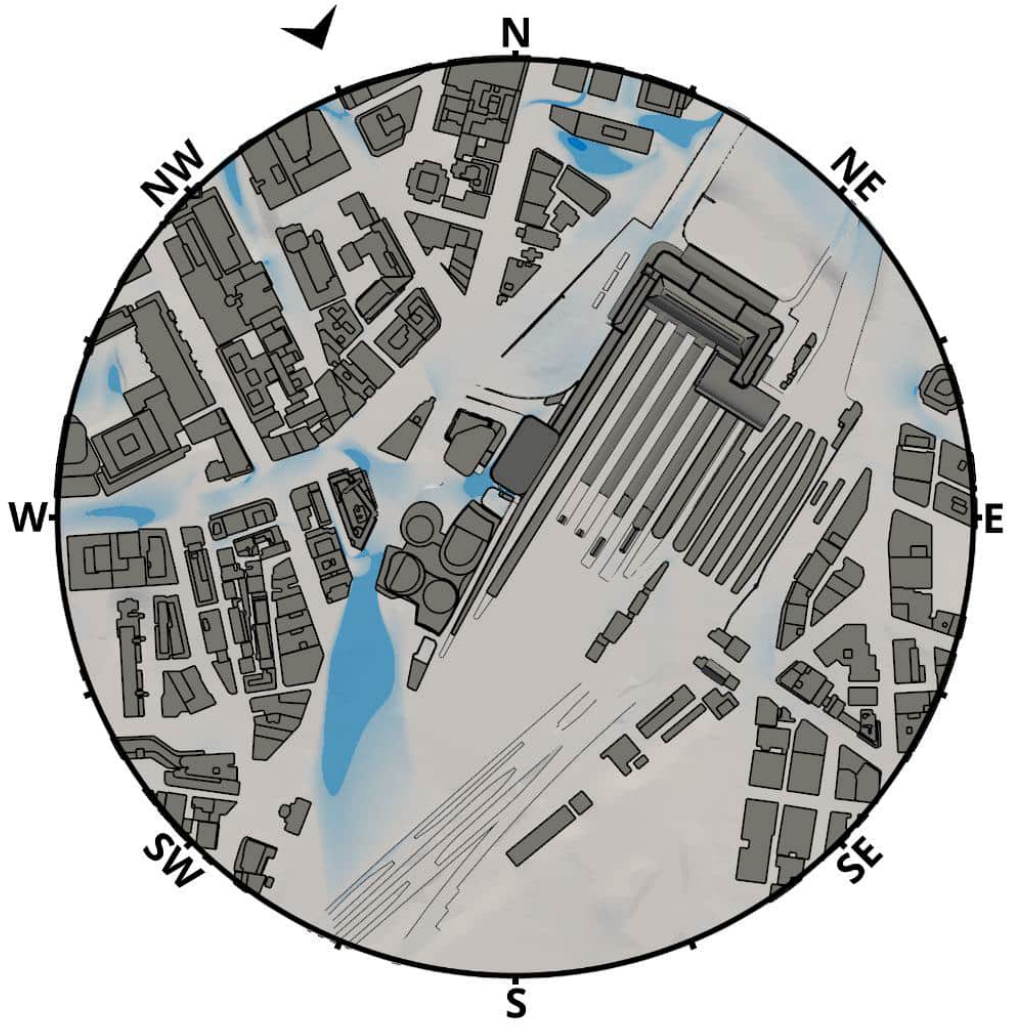


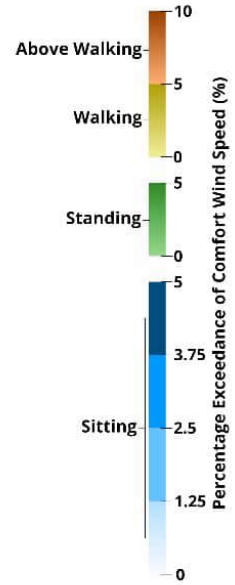


COMFORT CRITERIA - NORTH-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Existing



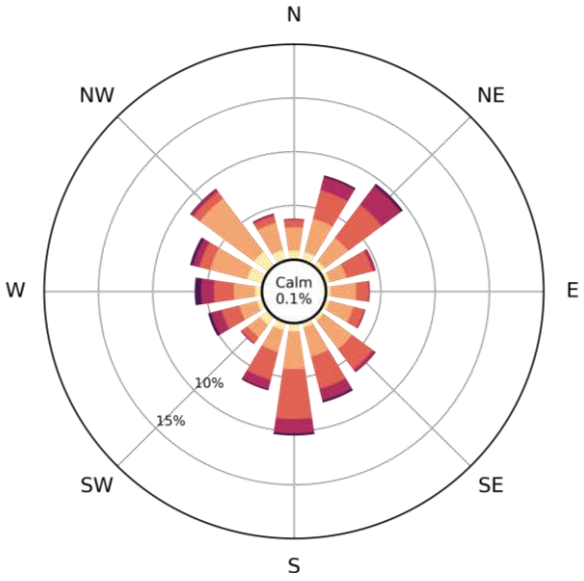


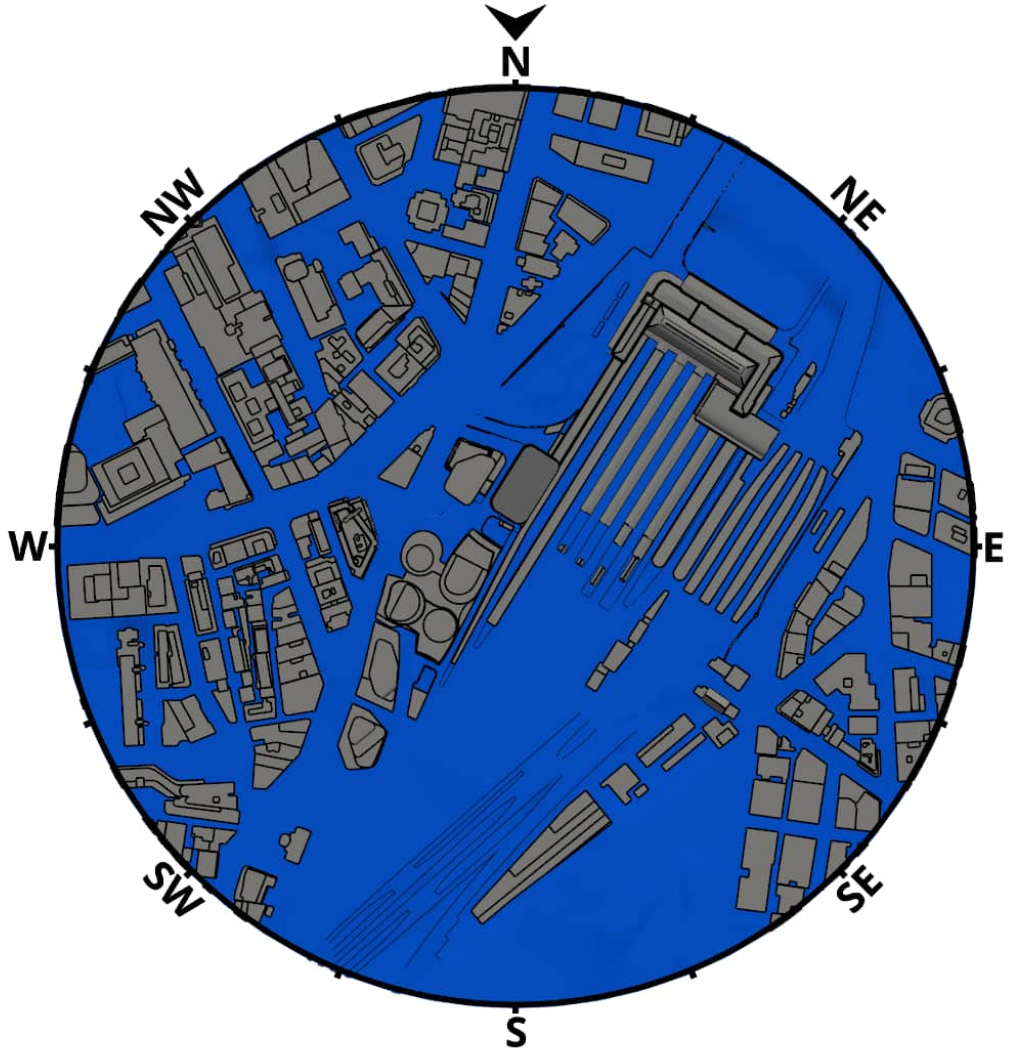


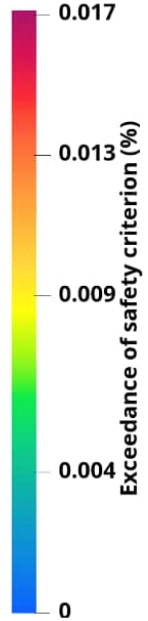
Option 1 - Directional Contributions - Safety

SAFETY CRITERIA - NORTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

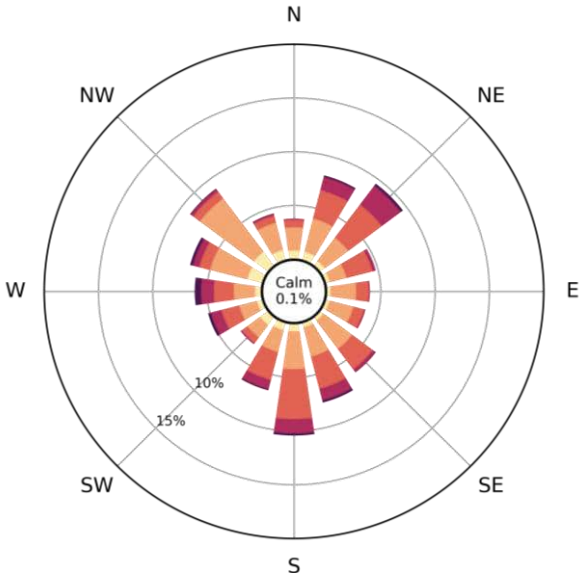


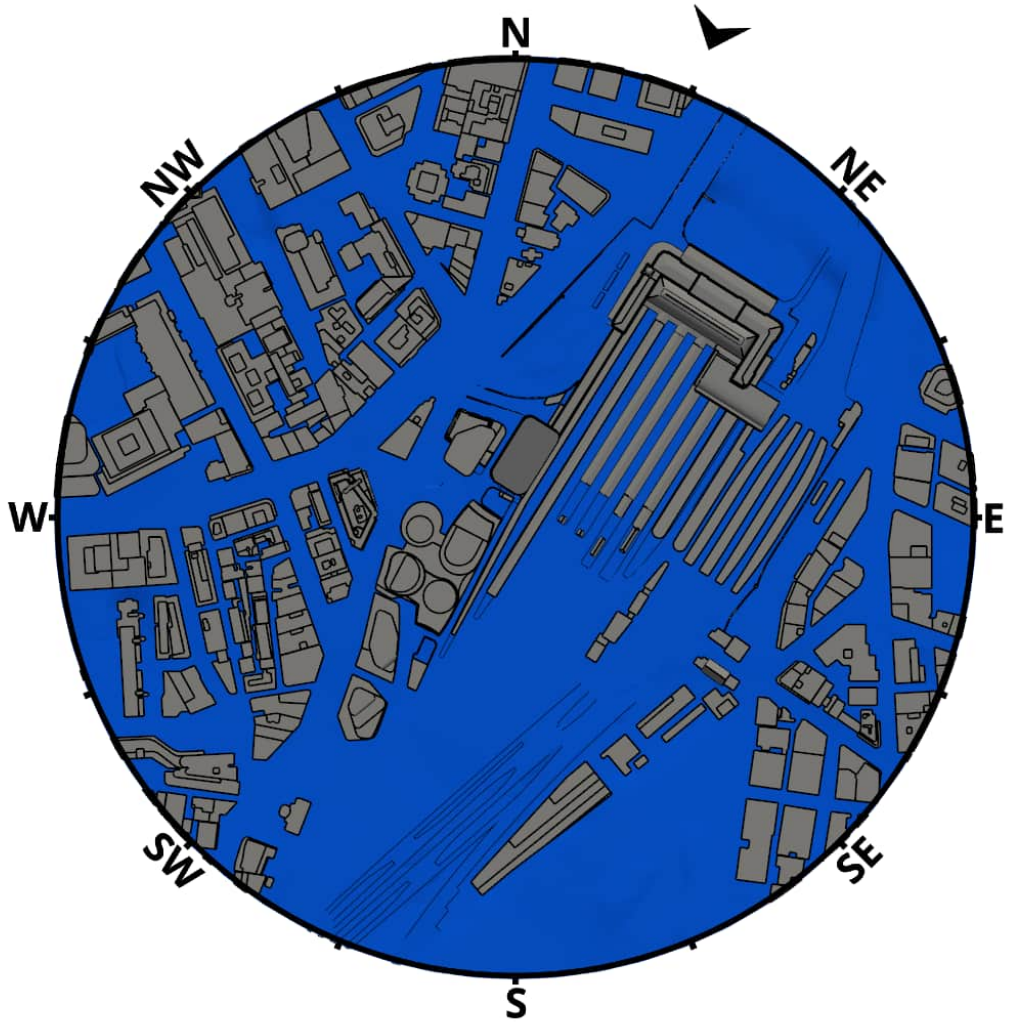


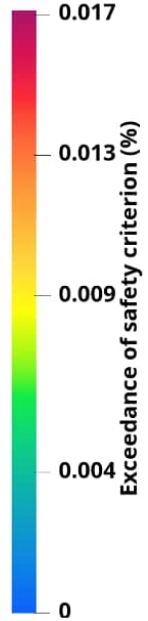


SAFETY CRITERIA - NORTH-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

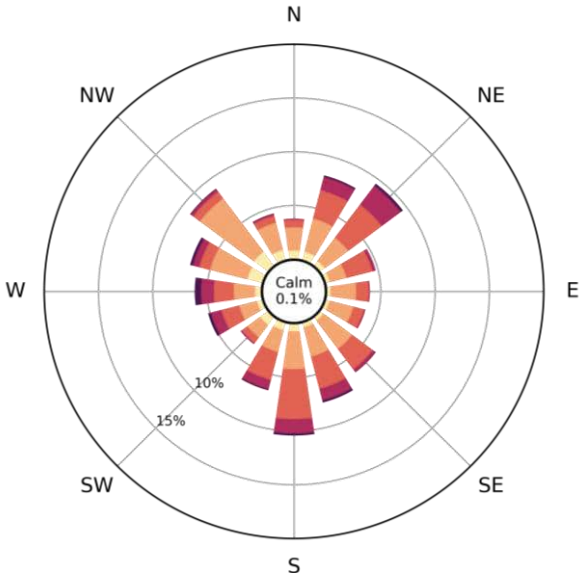


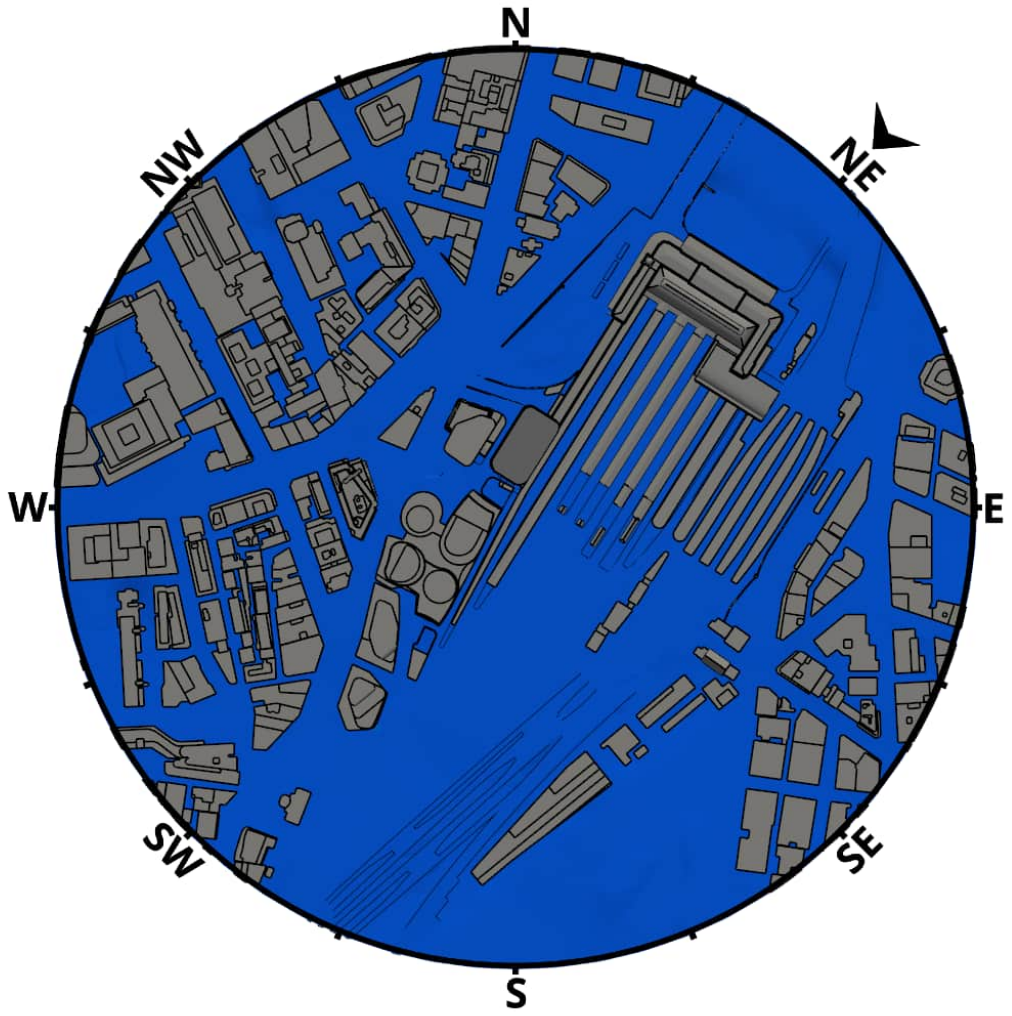


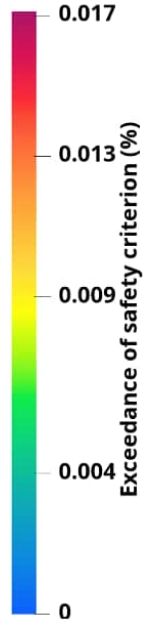


SAFETY CRITERIA - NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

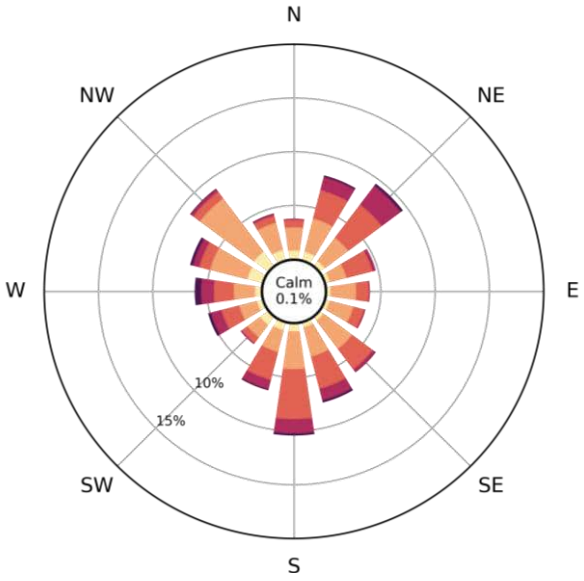


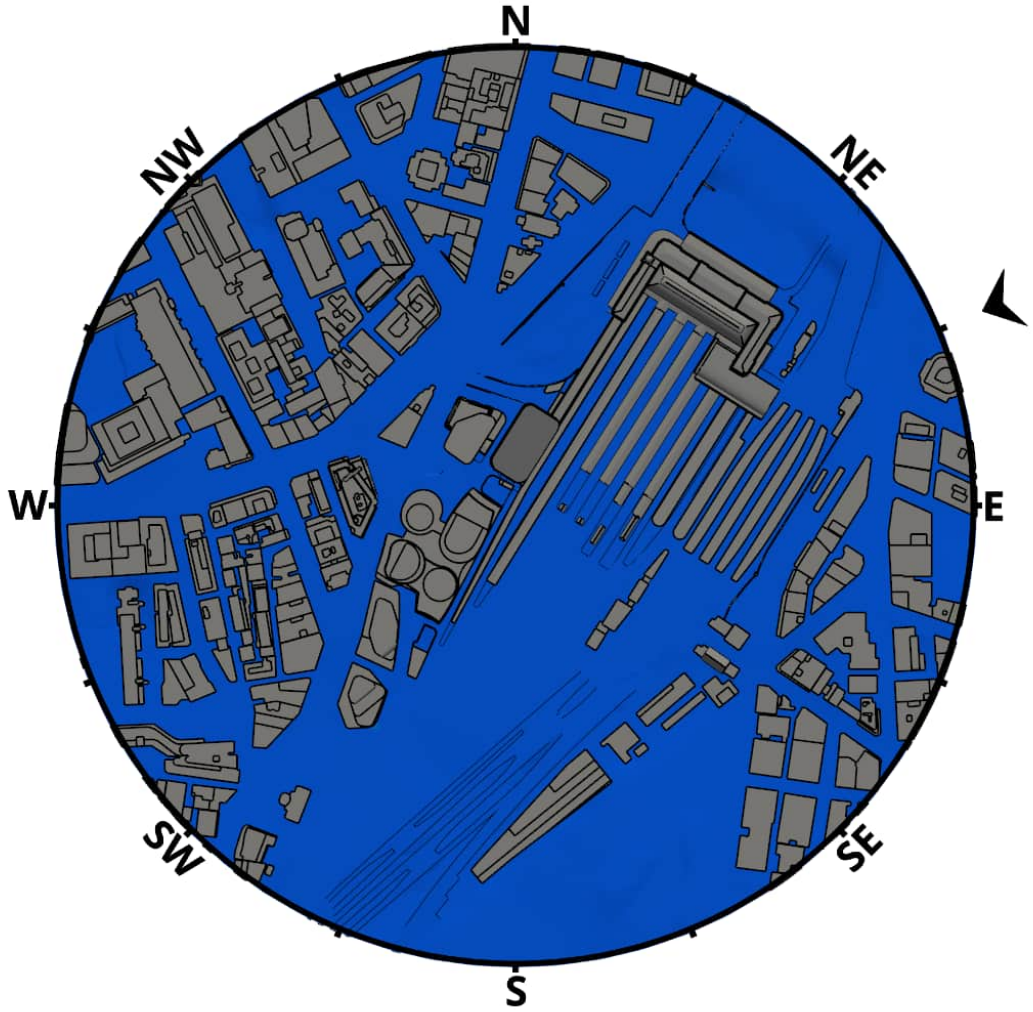


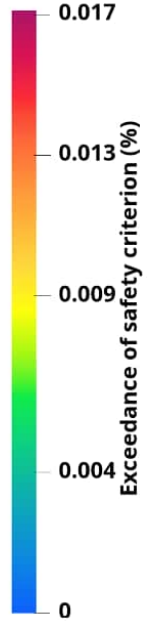


SAFETY CRITERIA - EAST-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

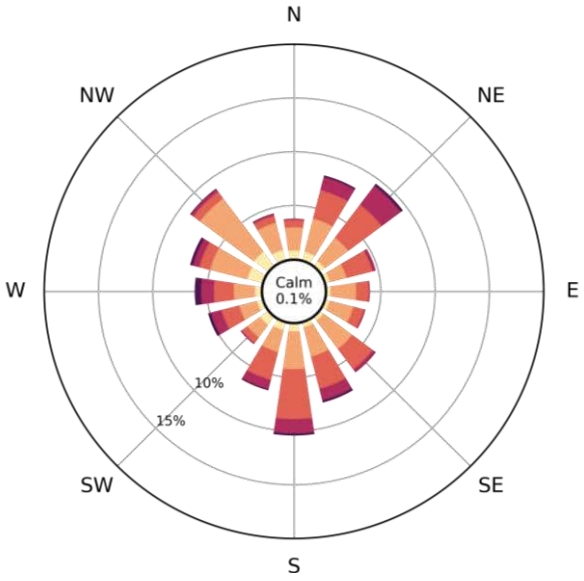


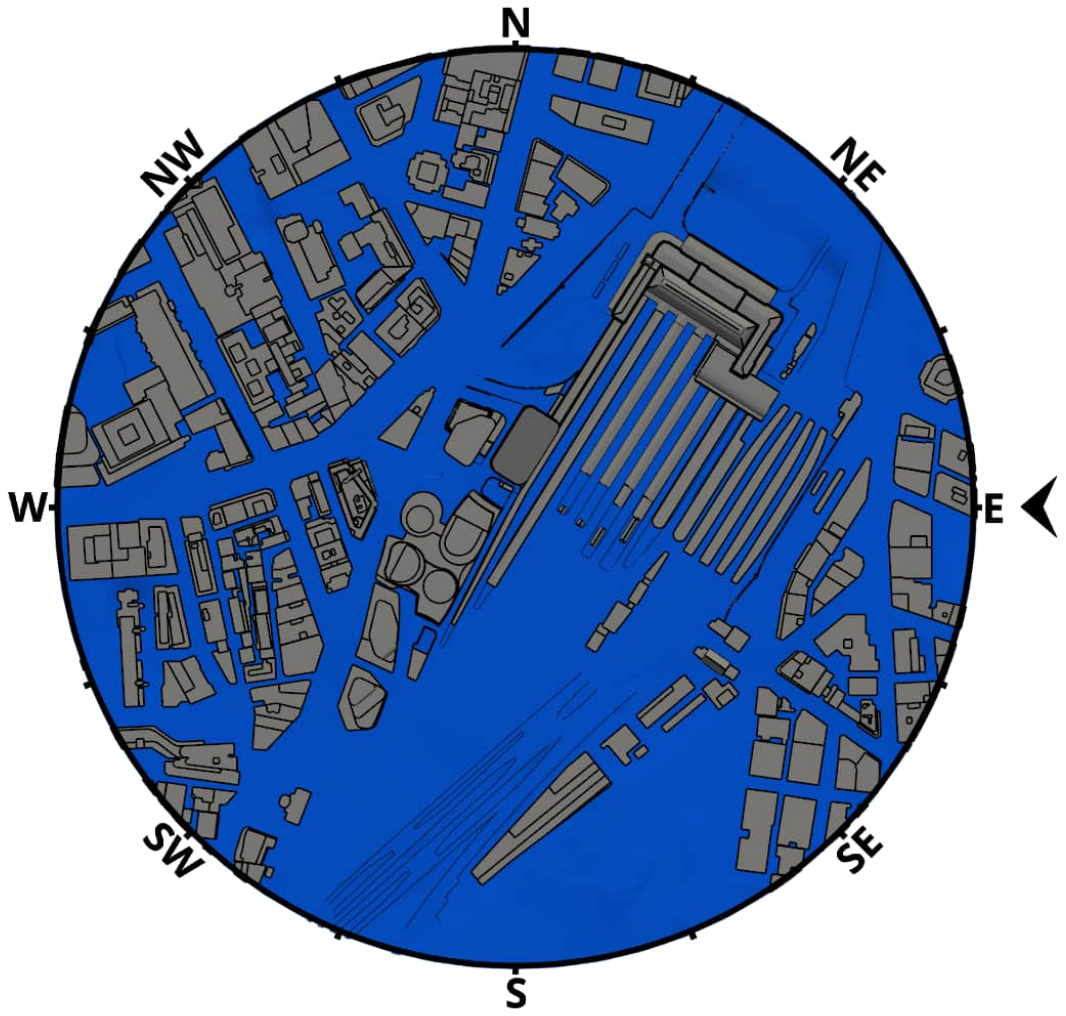


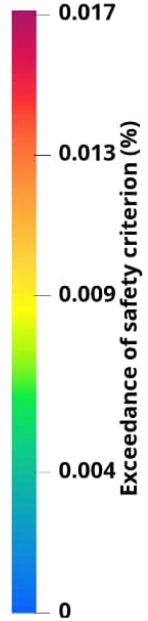


SAFETY CRITERIA - EAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

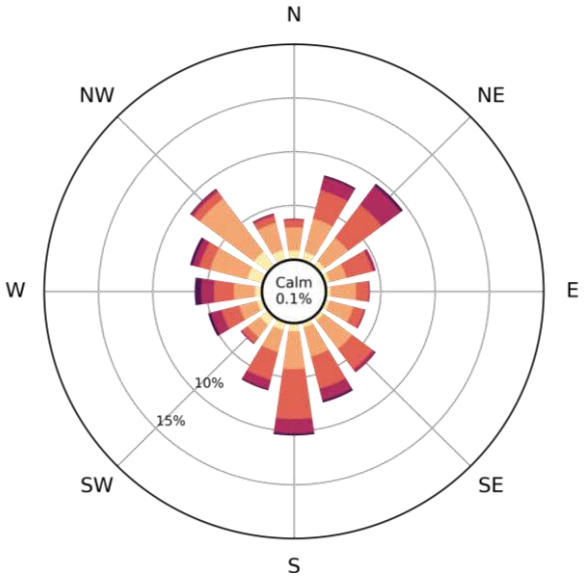


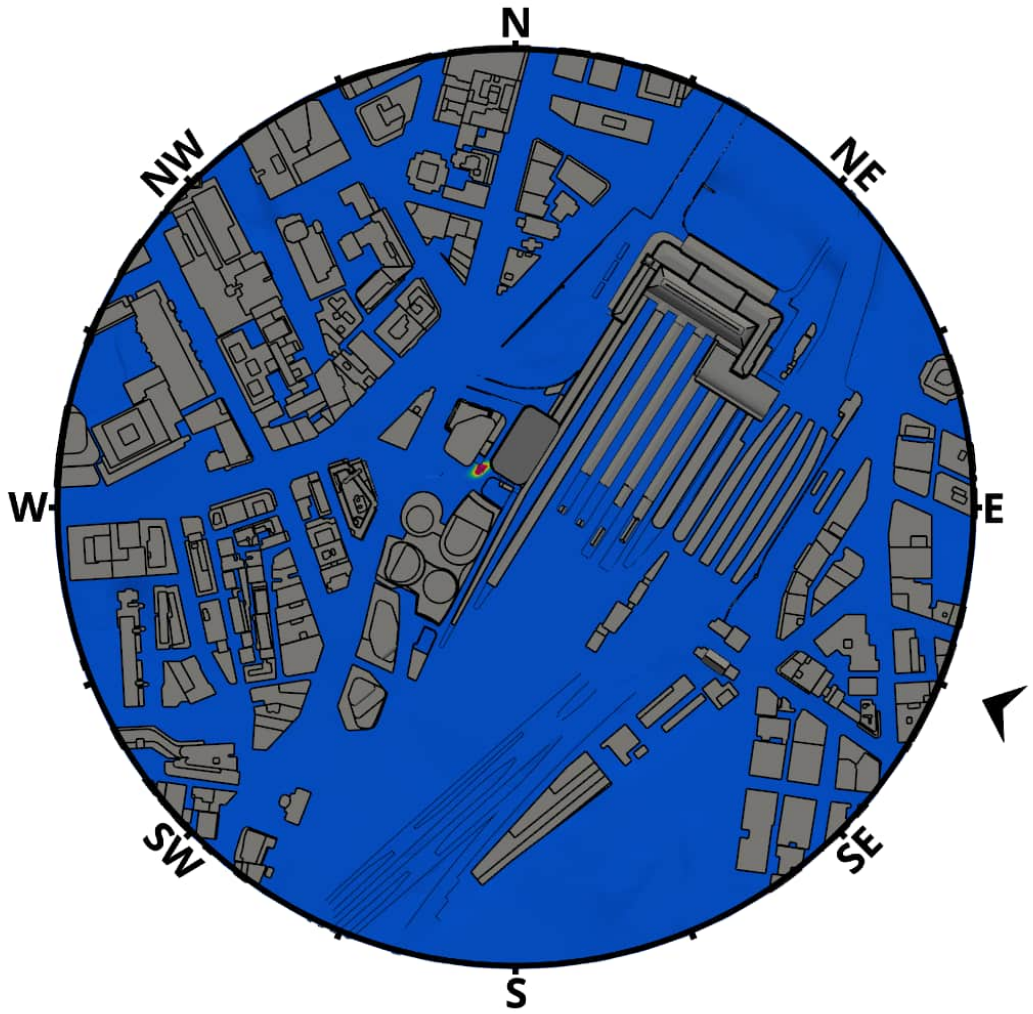


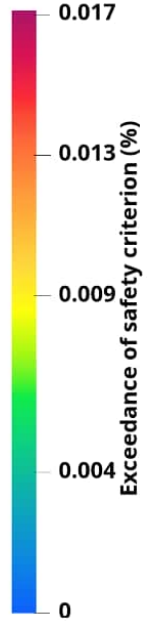


SAFETY CRITERIA - EAST-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

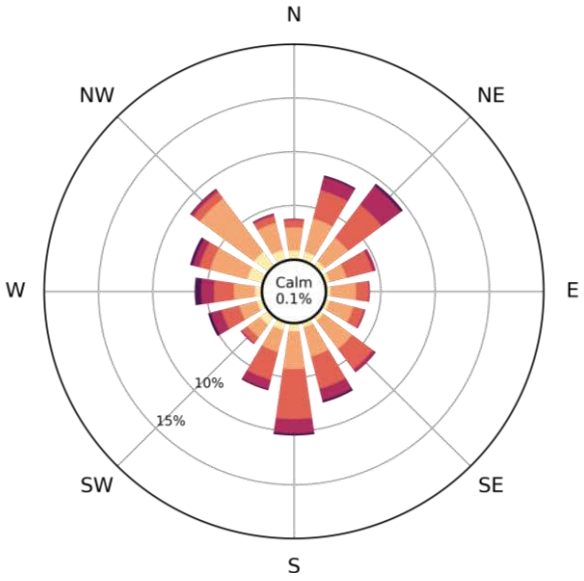


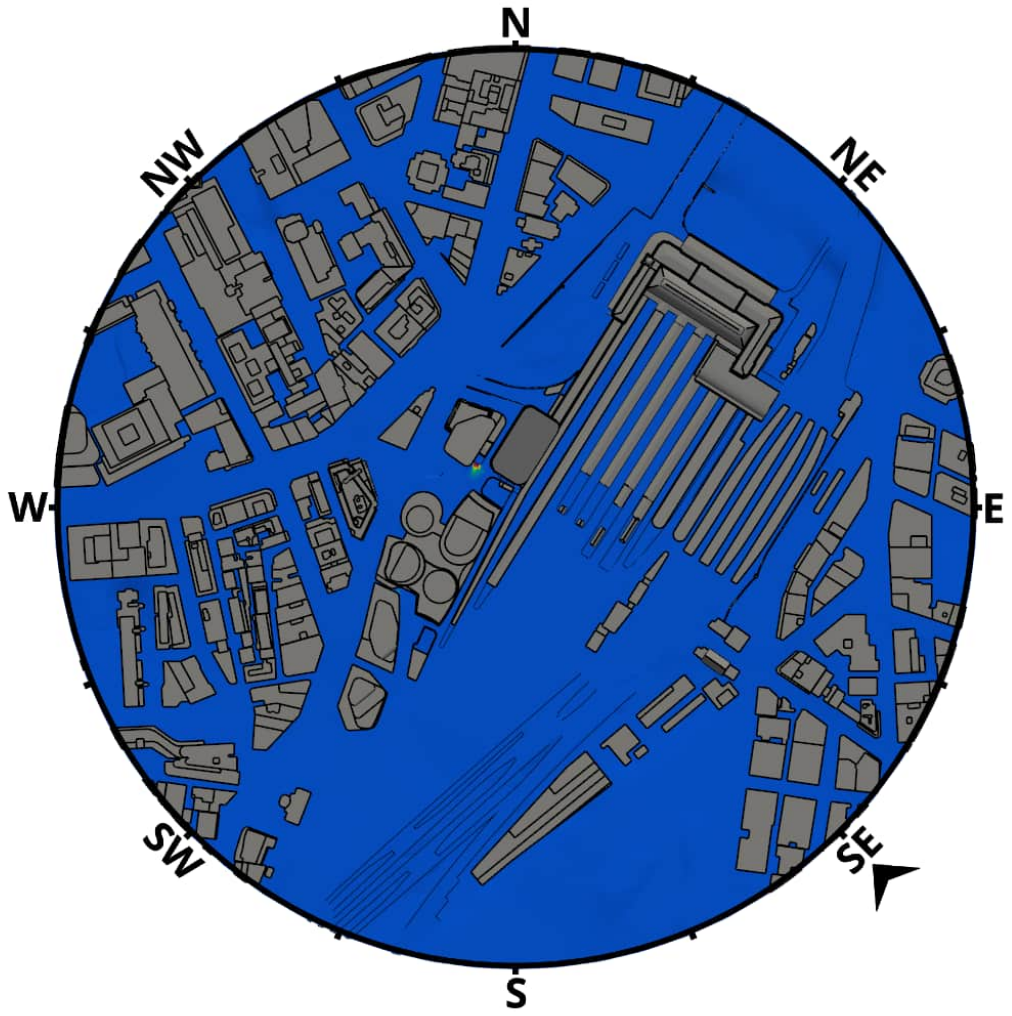


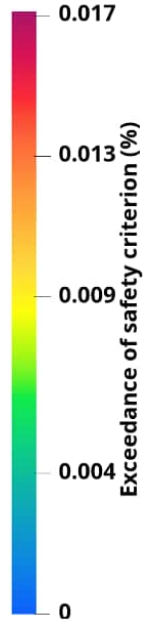


SAFETY CRITERIA - SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

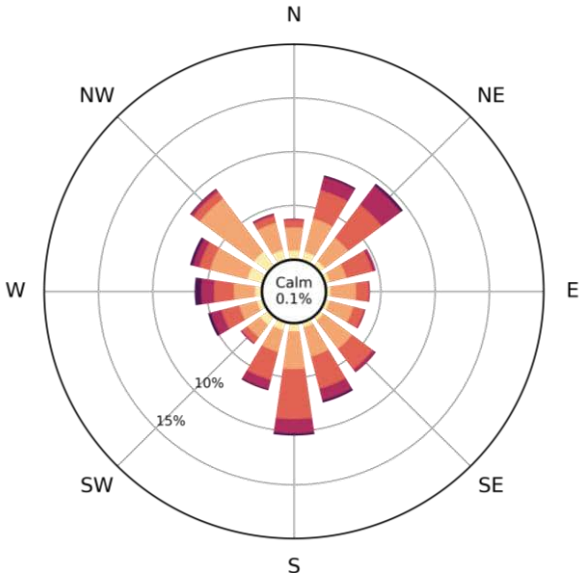


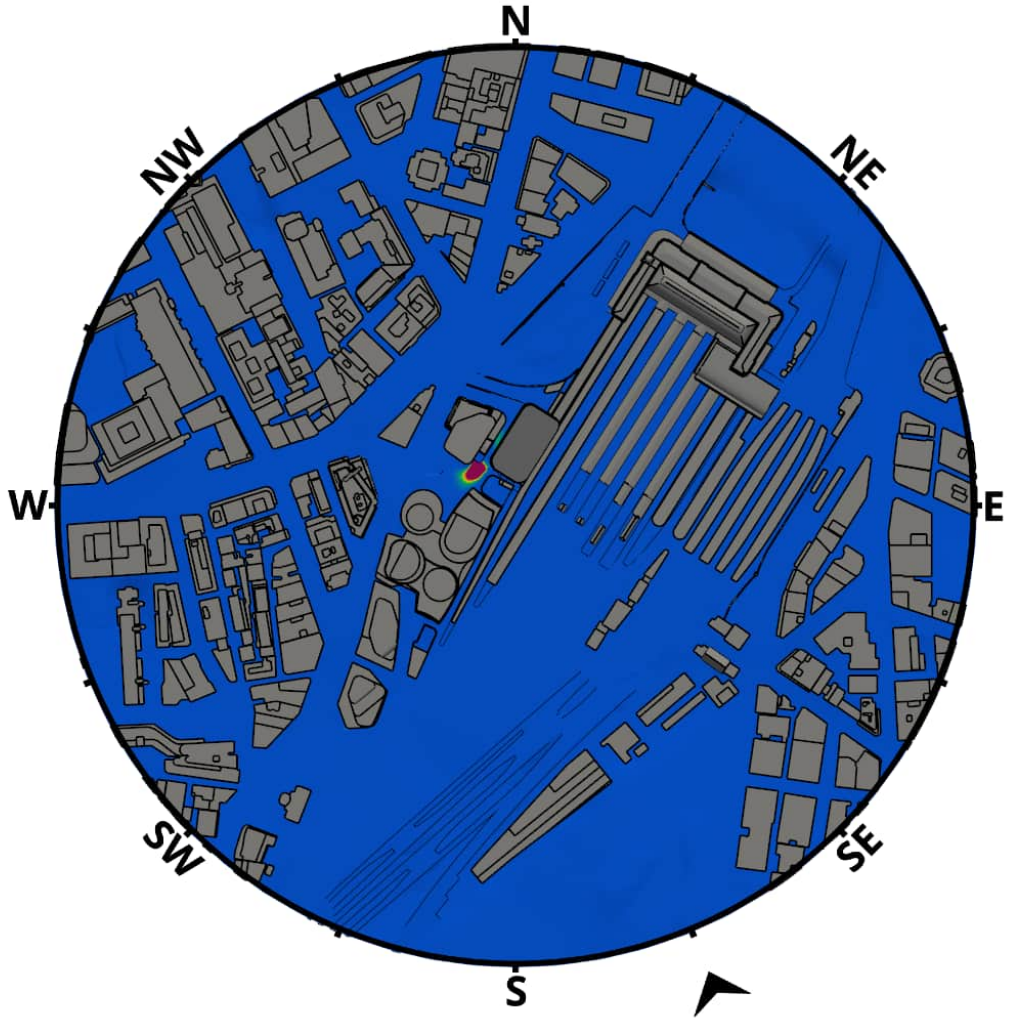


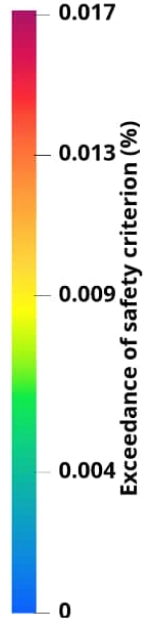


SAFETY CRITERIA - SOUTH-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

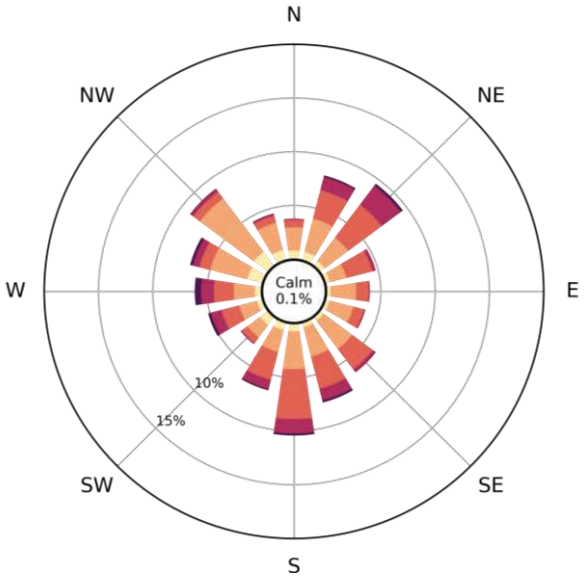


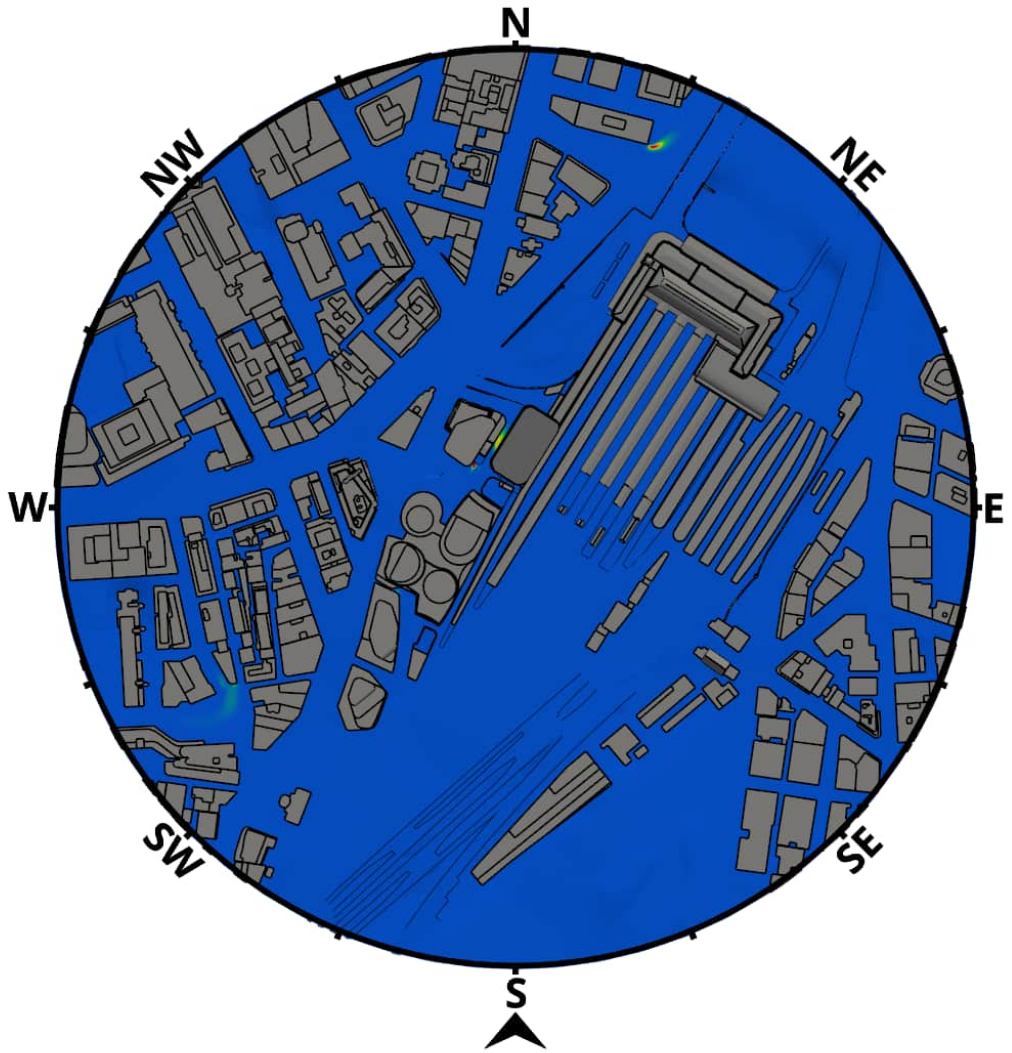


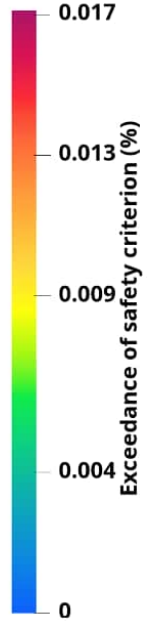


SAFETY CRITERIA - SOUTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

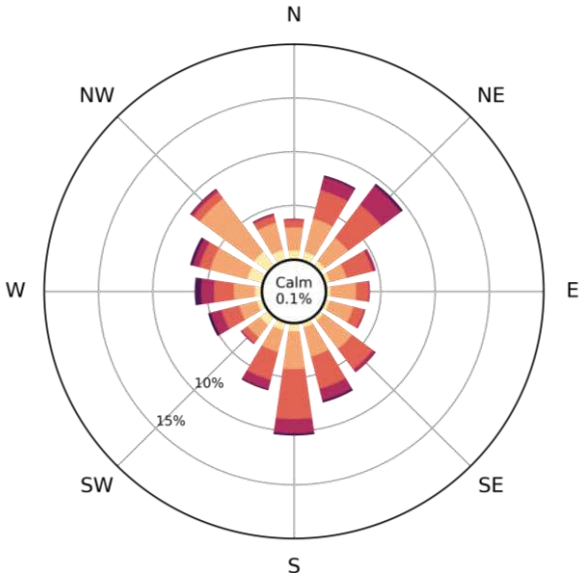


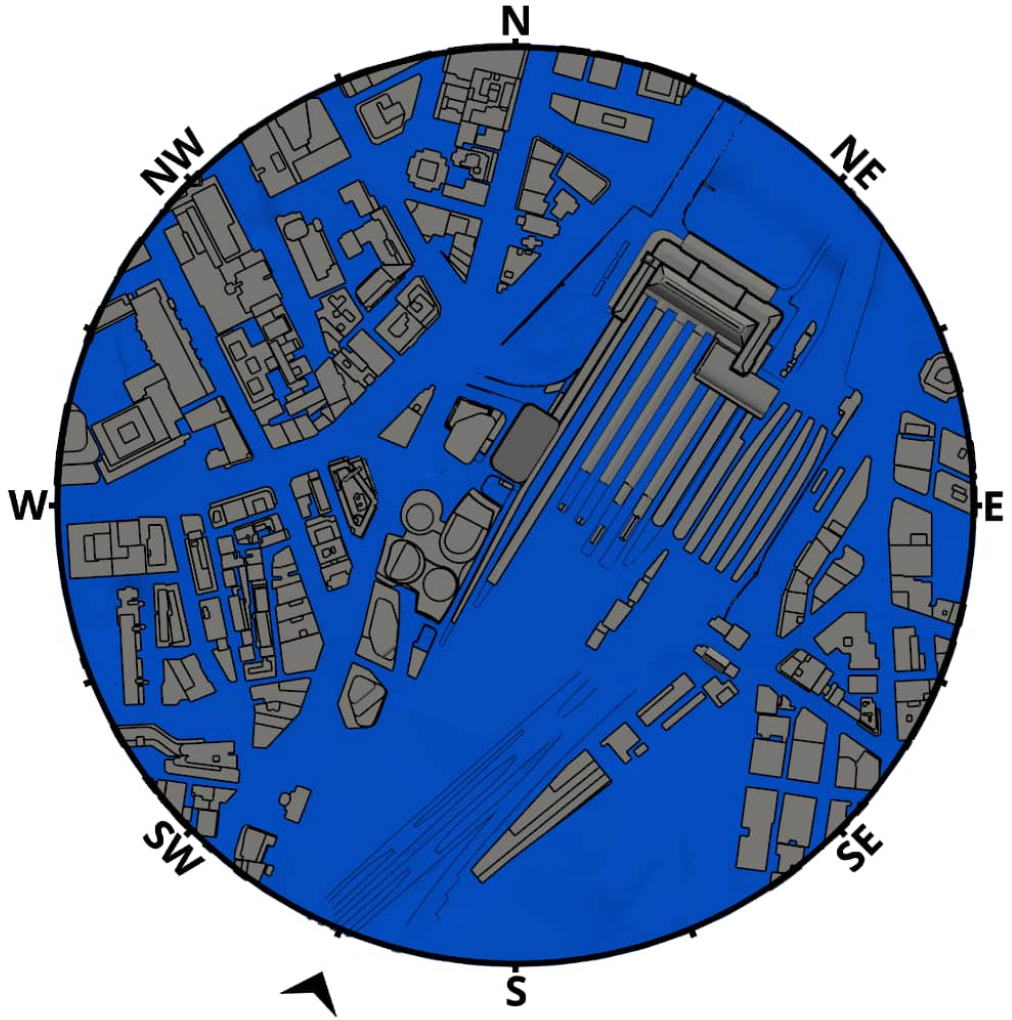


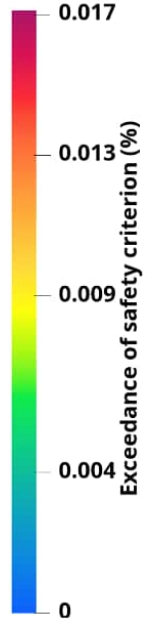


SAFETY CRITERIA - SOUTH-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

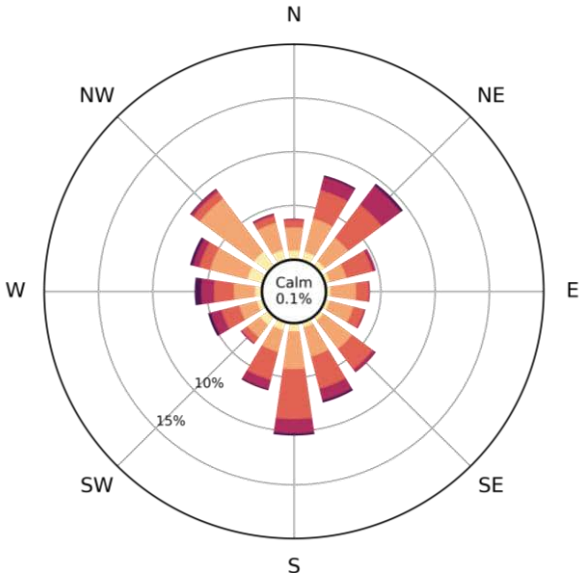


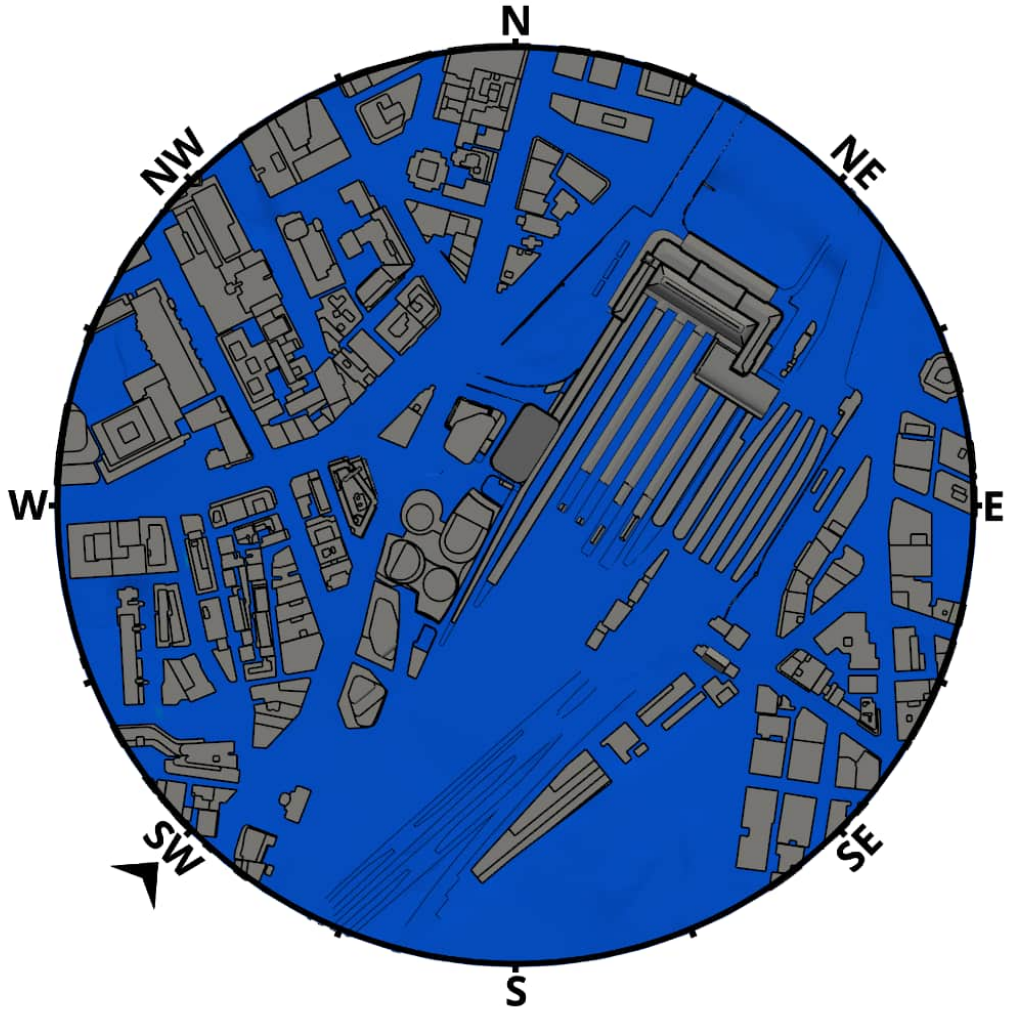


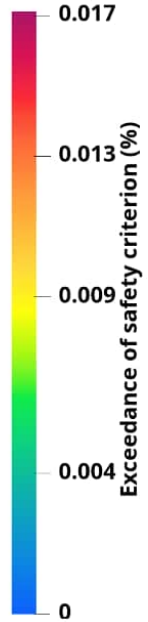


SAFETY CRITERIA - SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

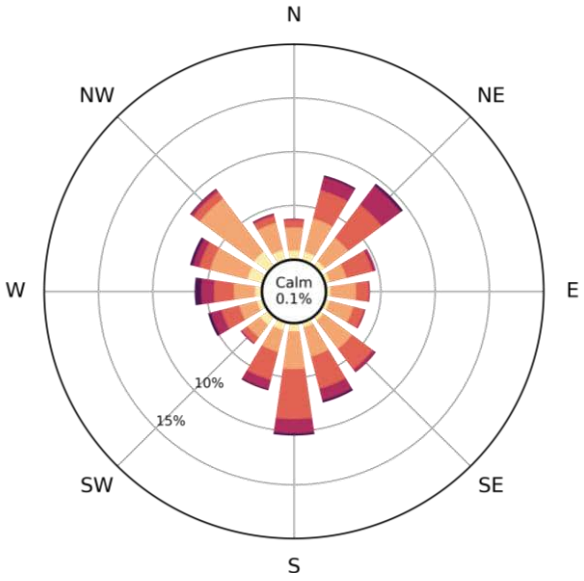


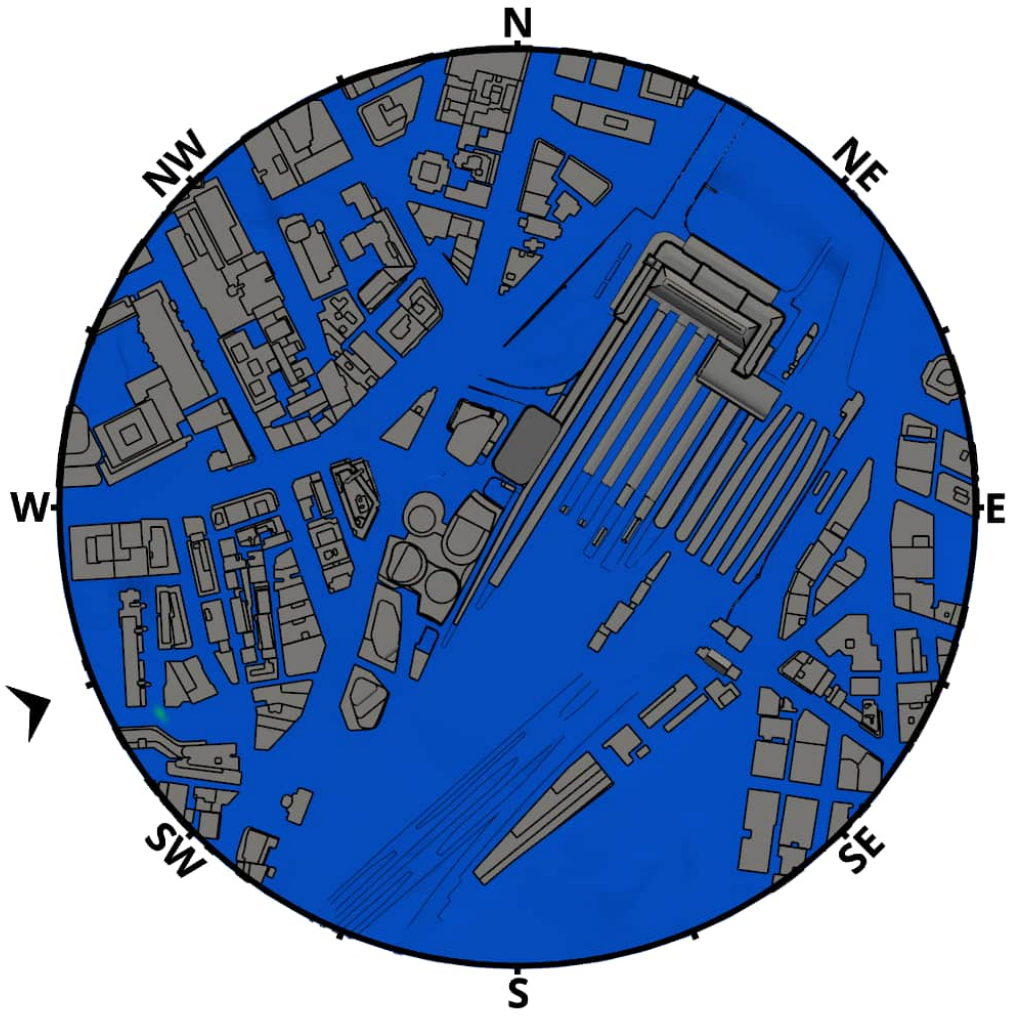


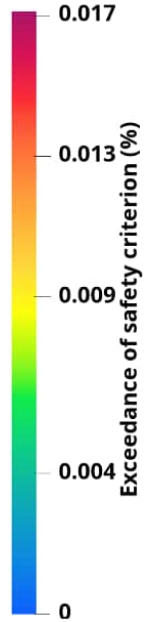


SAFETY CRITERIA - WEST-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

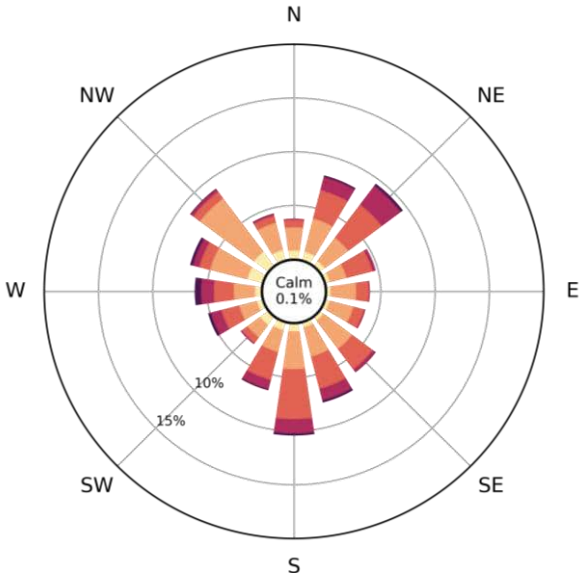


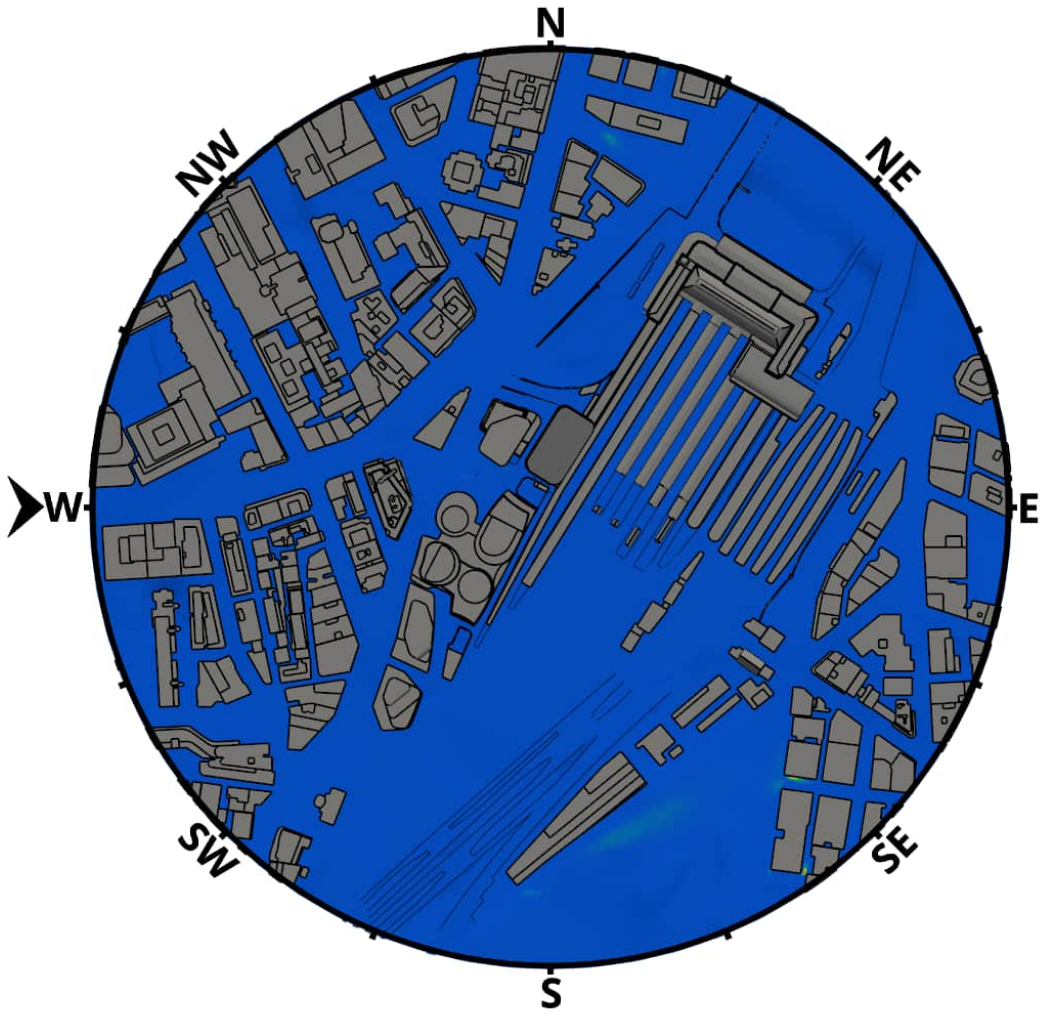


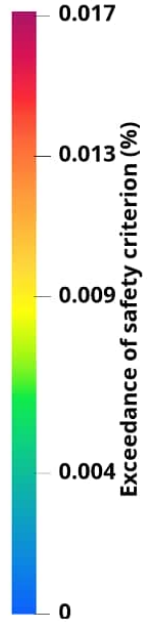


SAFETY CRITERIA - WEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

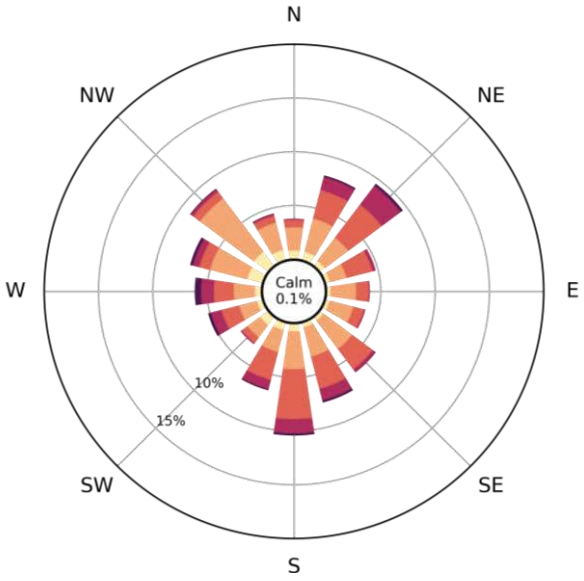


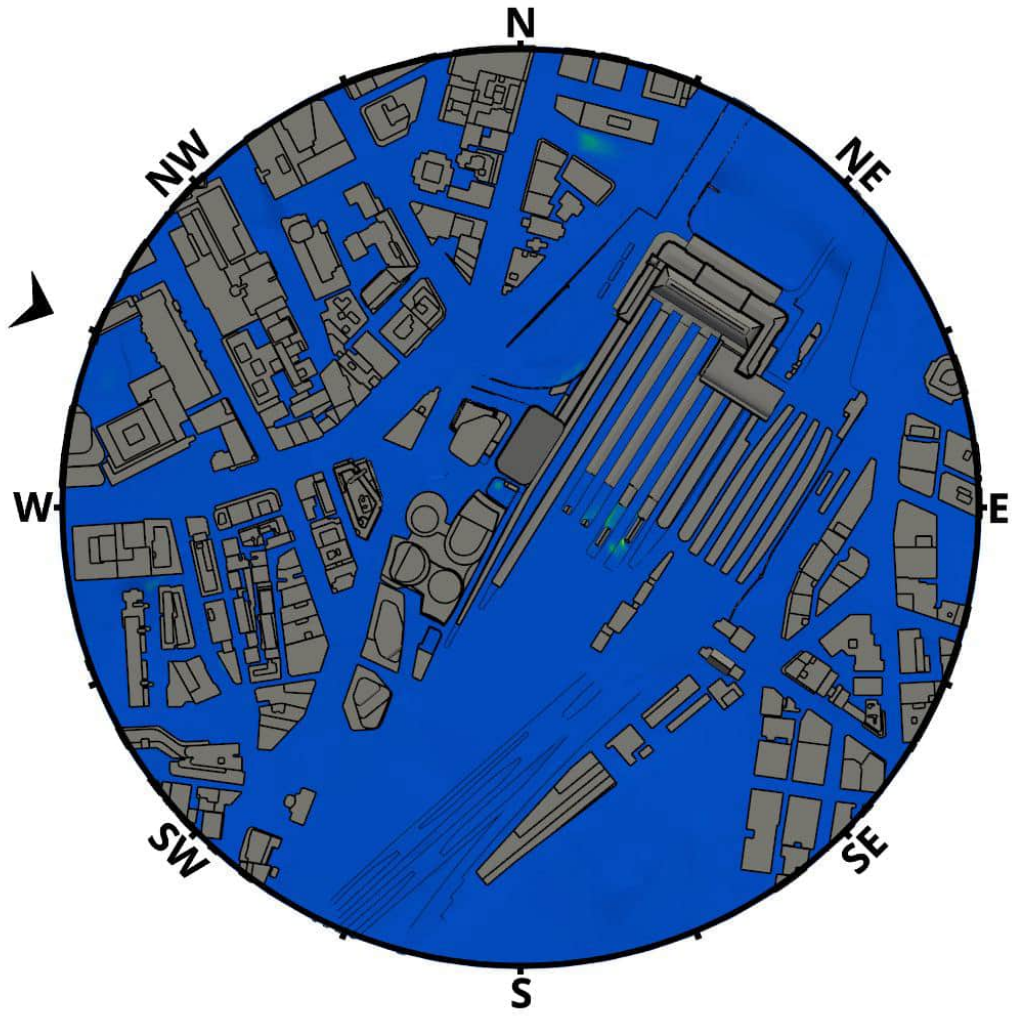


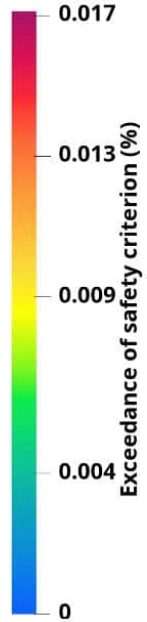


SAFETY CRITERIA - WEST-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

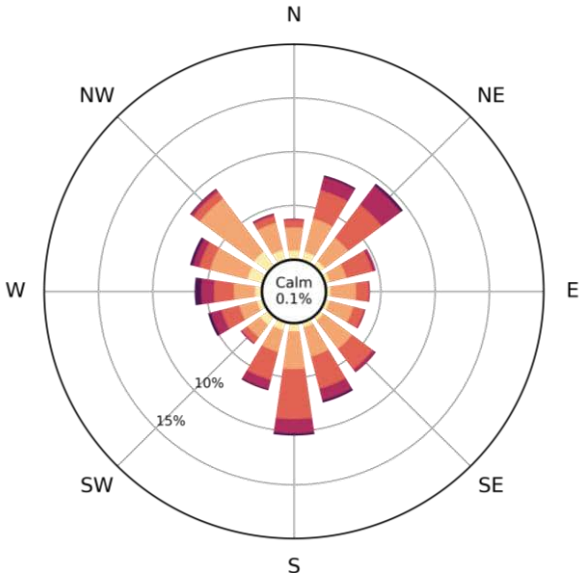


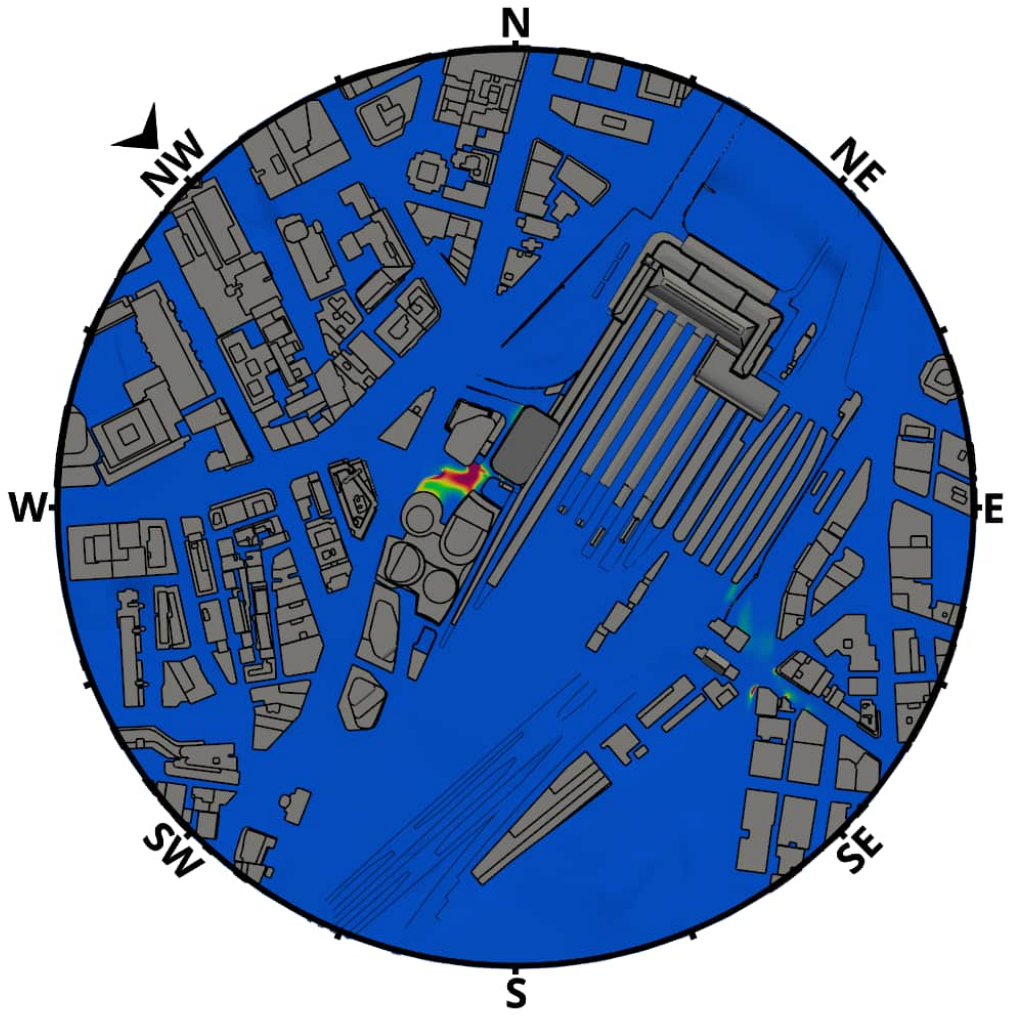


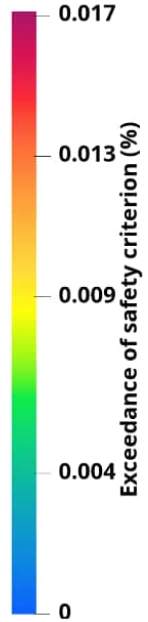


SAFETY CRITERIA - NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

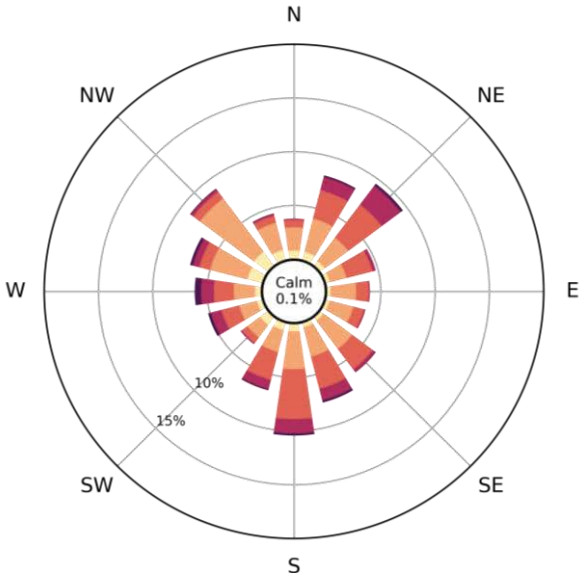


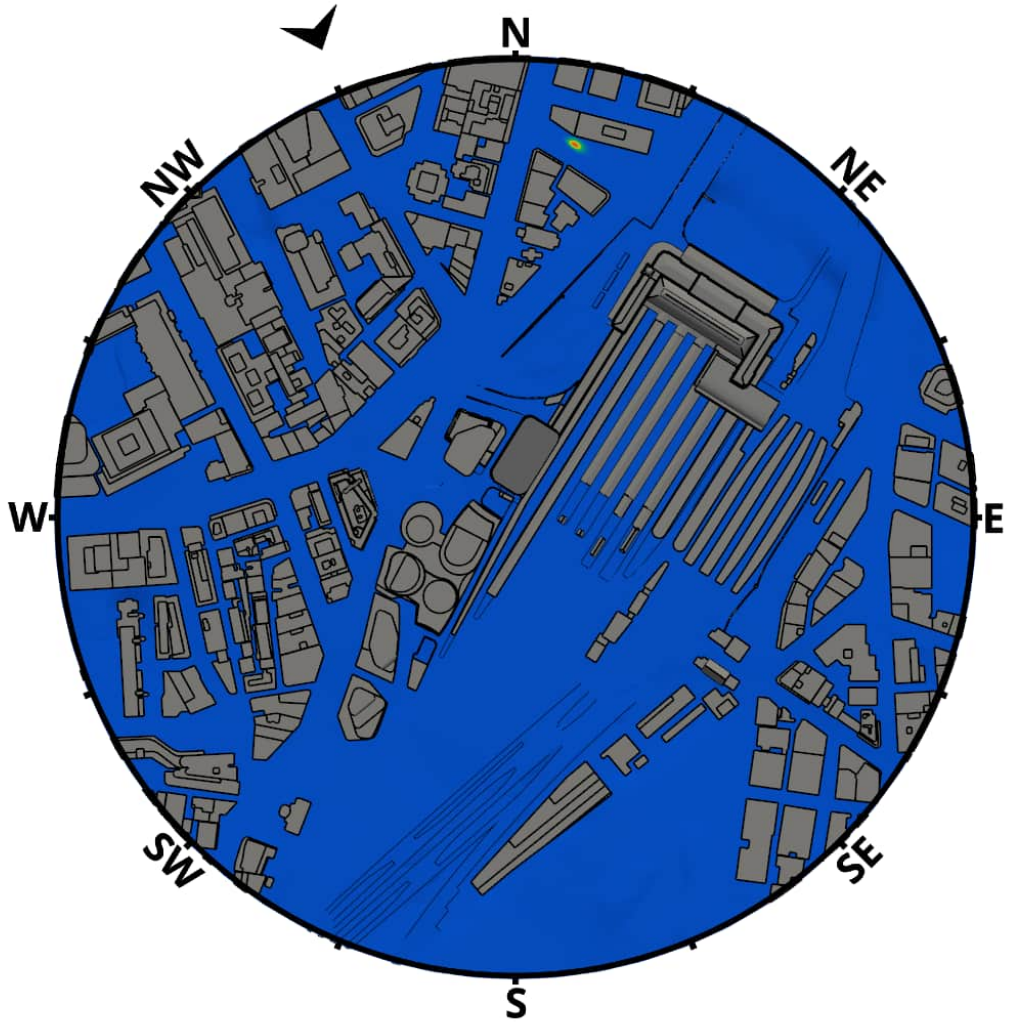


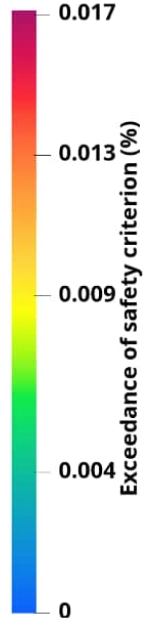


SAFETY CRITERIA - NORTH-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline



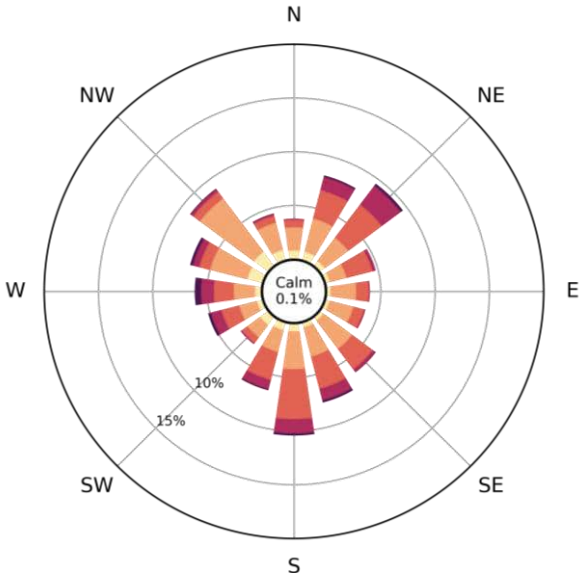


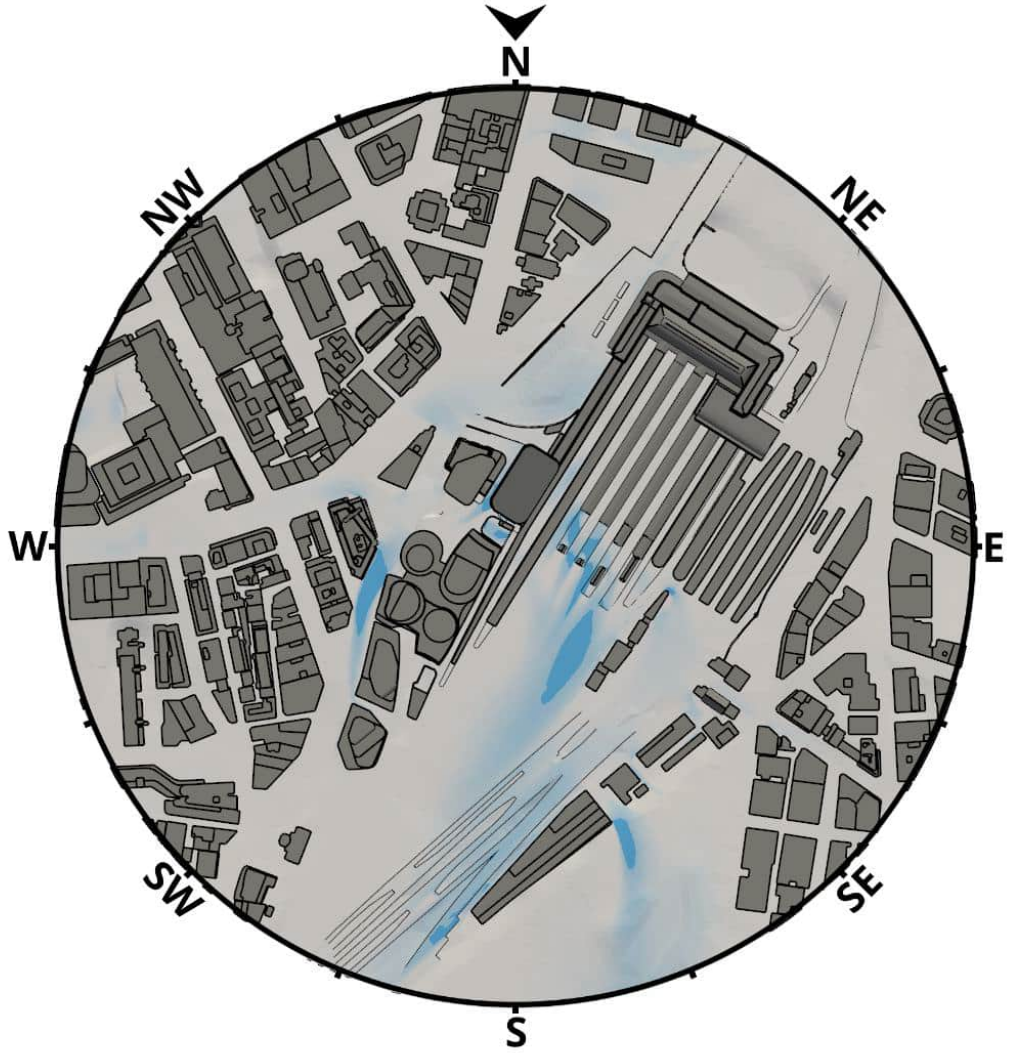


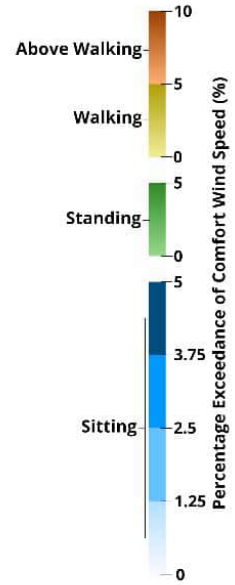
Option 1 - Directional Contributions - Comfort

COMFORT CRITERIA - NORTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

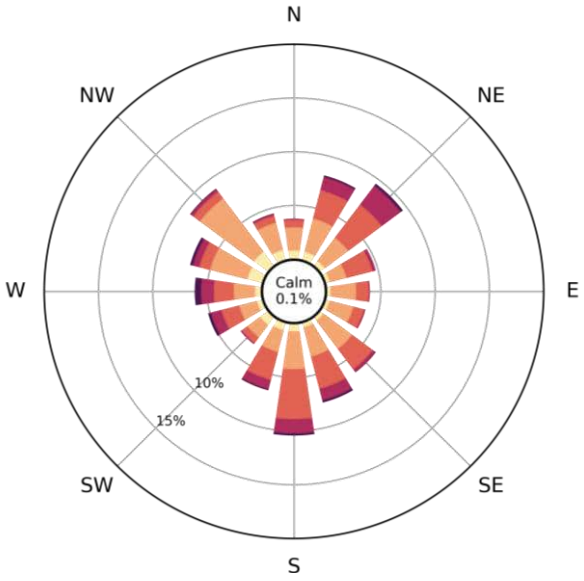


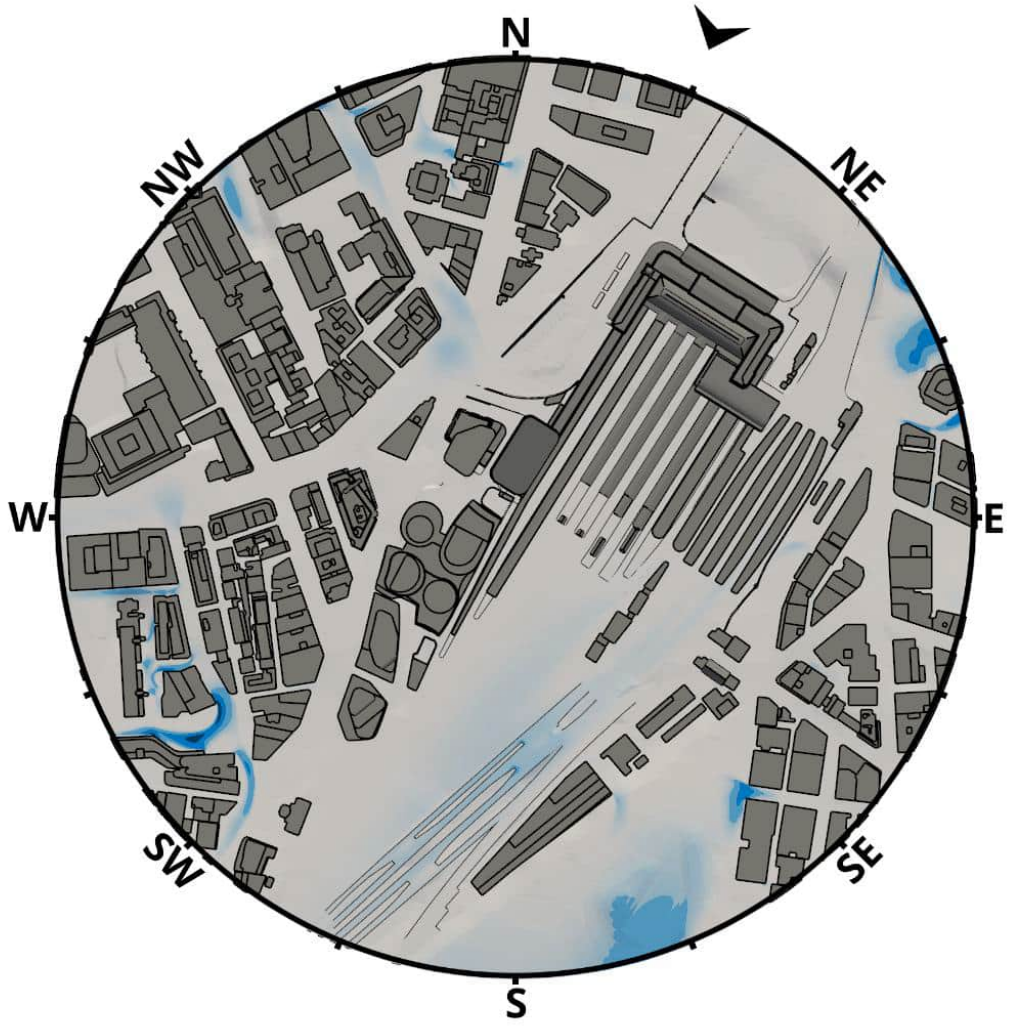


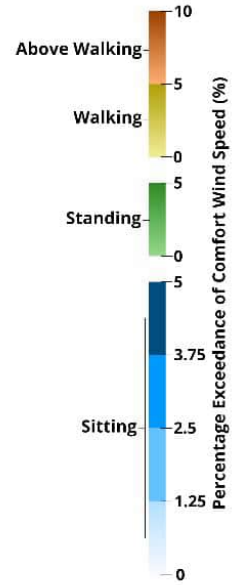


COMFORT CRITERIA - NORTH-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

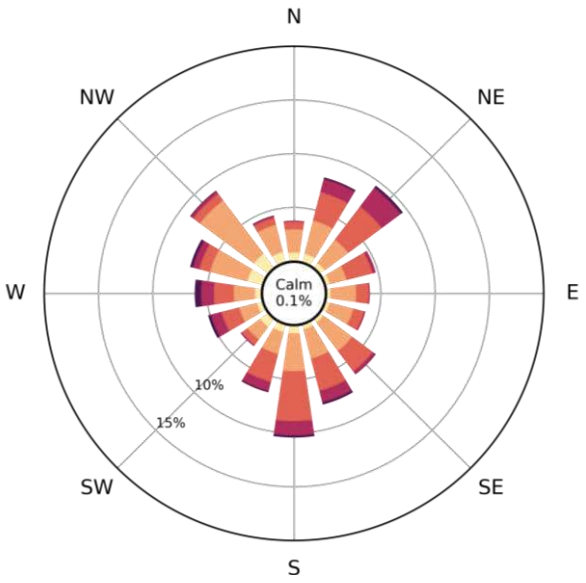


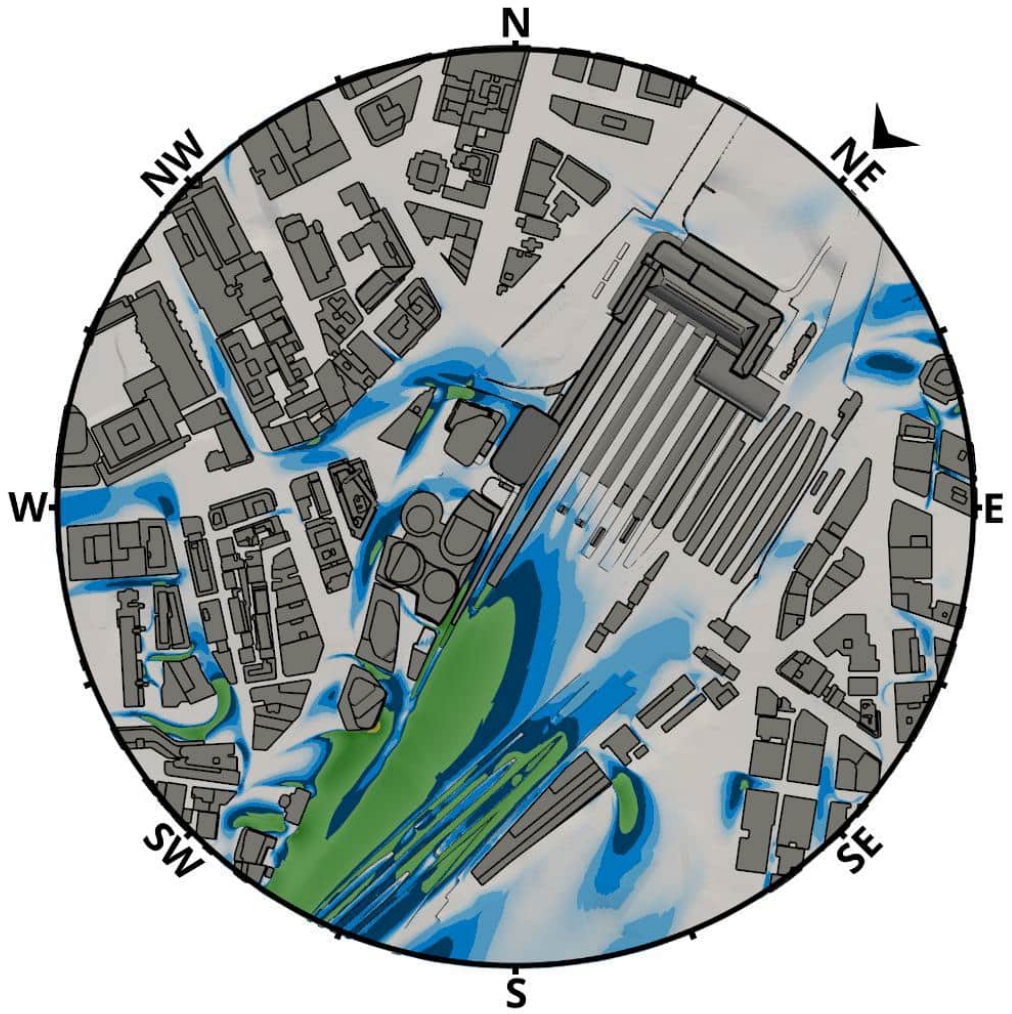


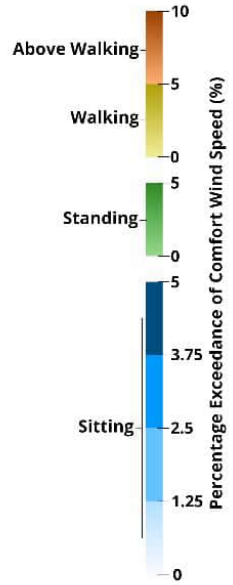


COMFORT CRITERIA - NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

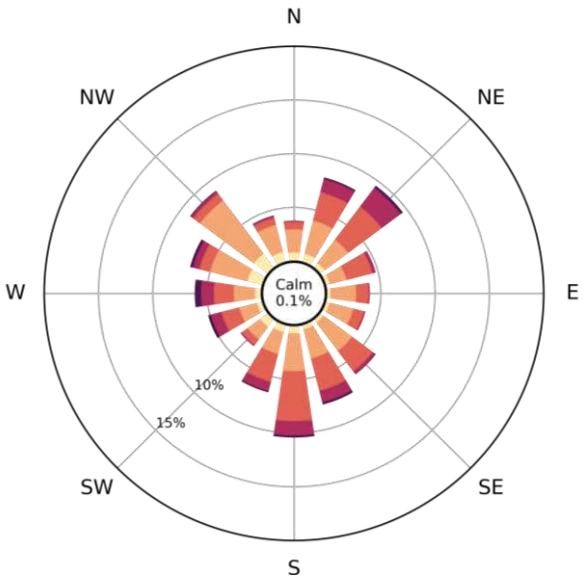


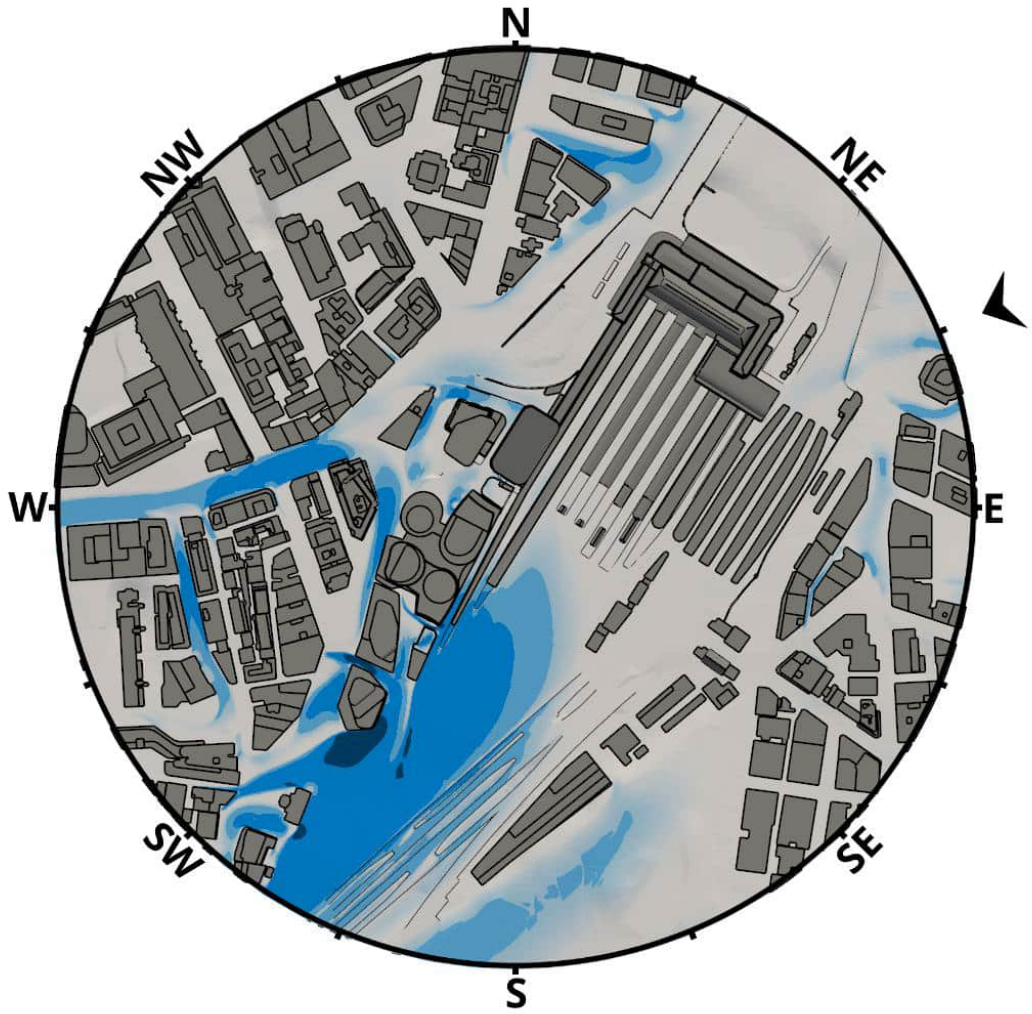


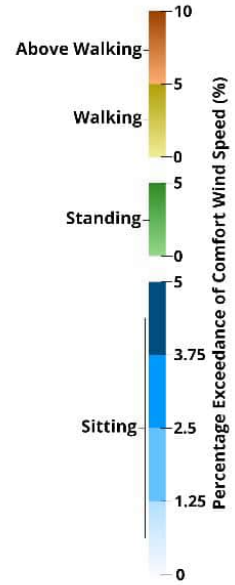


COMFORT CRITERIA - EAST-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

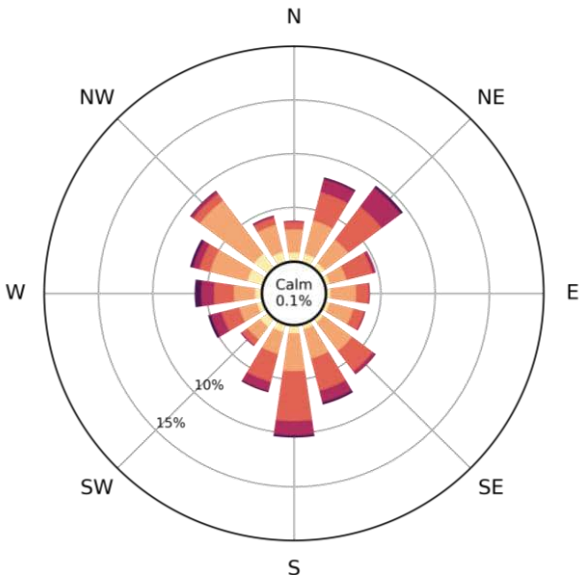


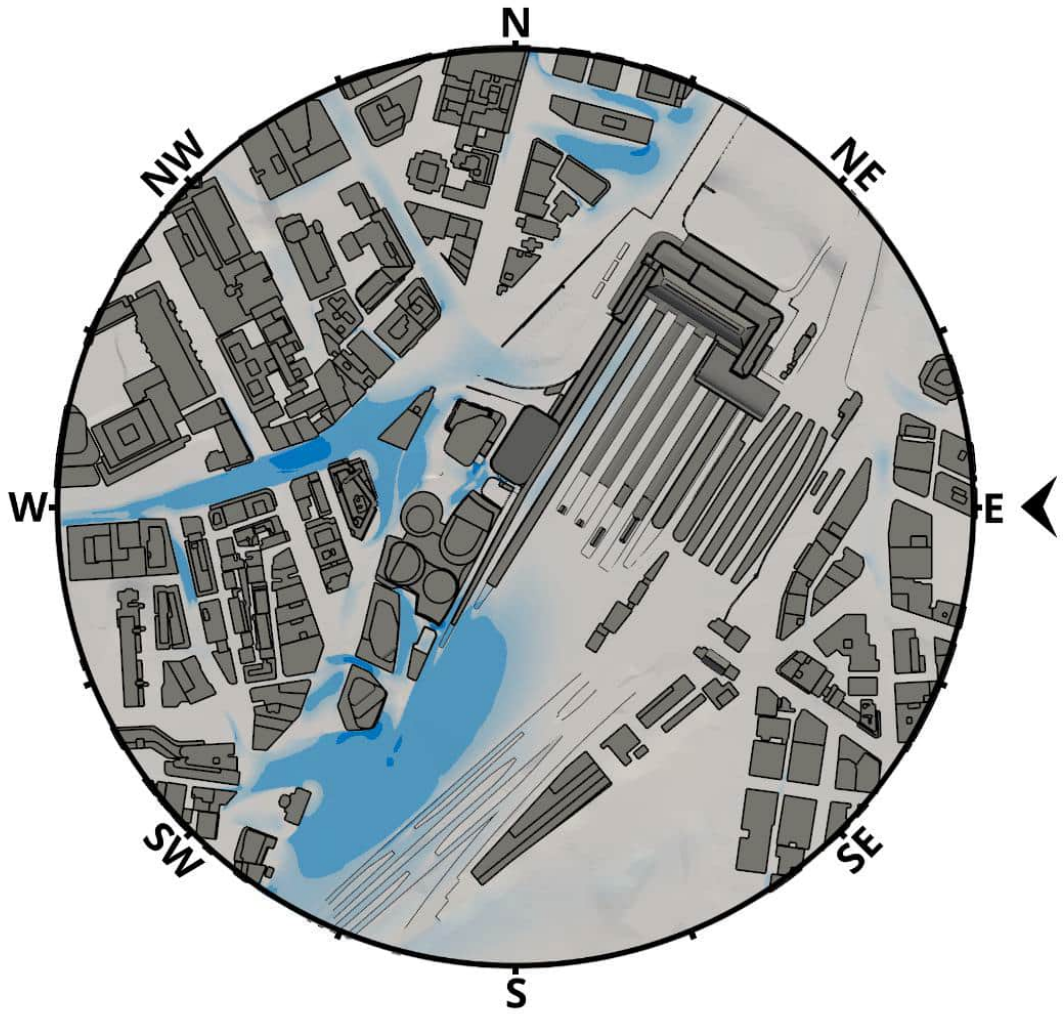


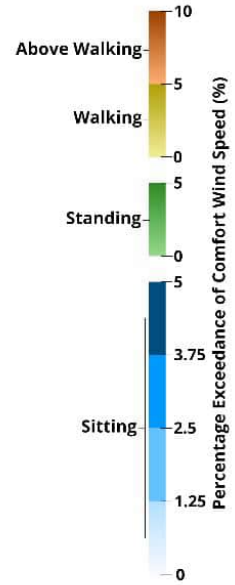


COMFORT CRITERIA - EAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

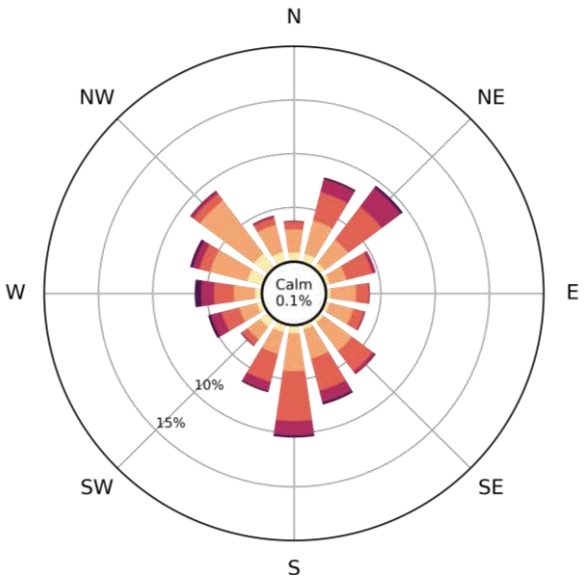


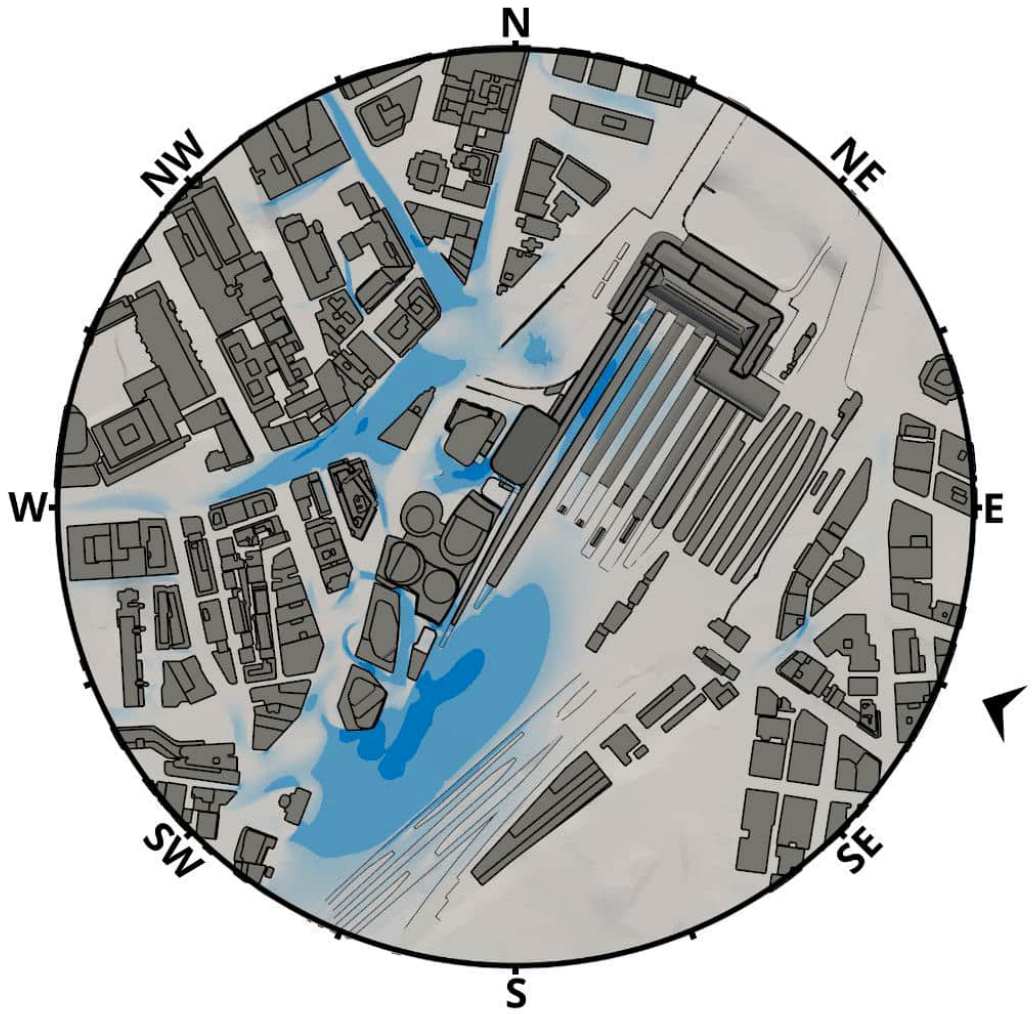


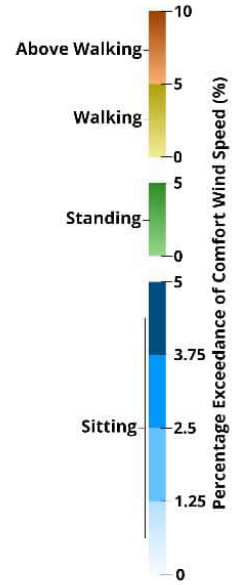


COMFORT CRITERIA - EAST-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

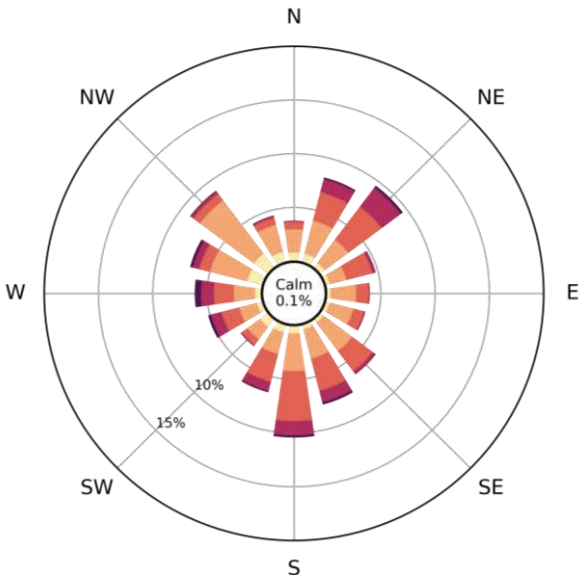


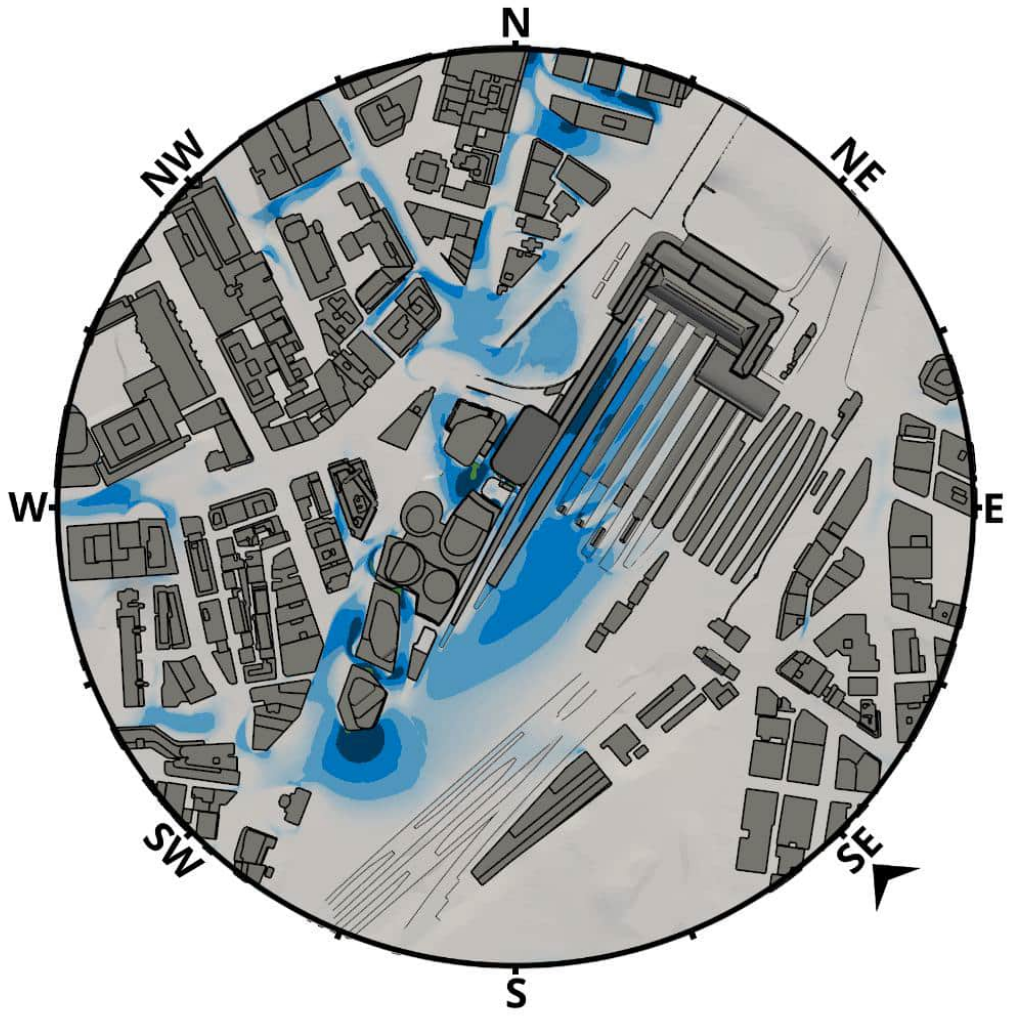


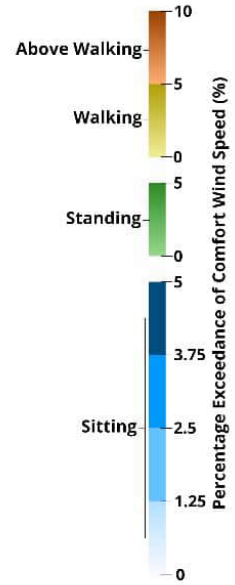


COMFORT CRITERIA - SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

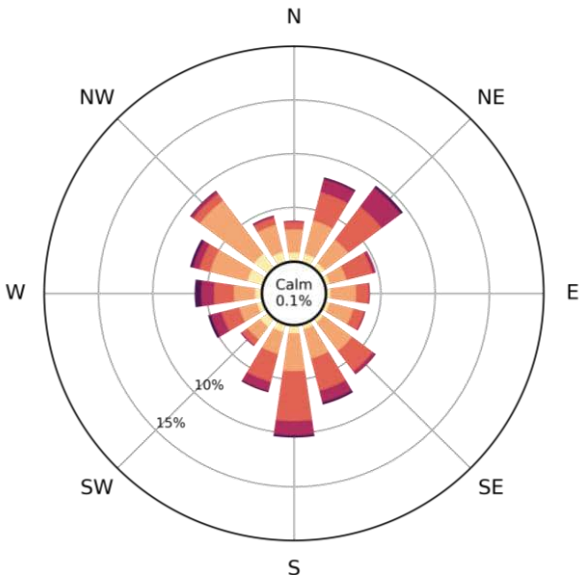


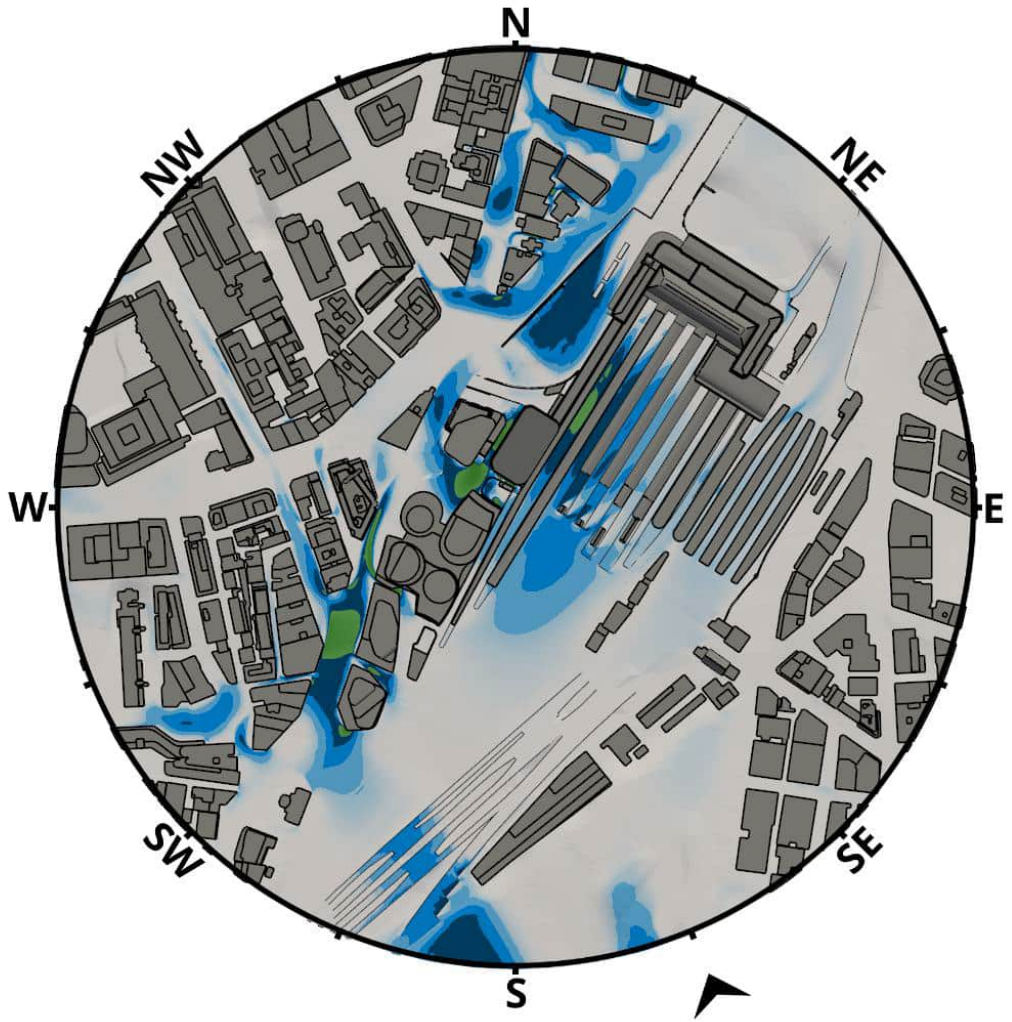


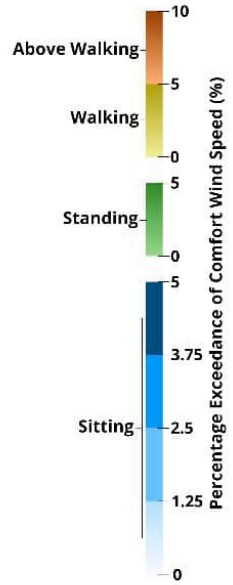


COMFORT CRITERIA - SOUTH-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

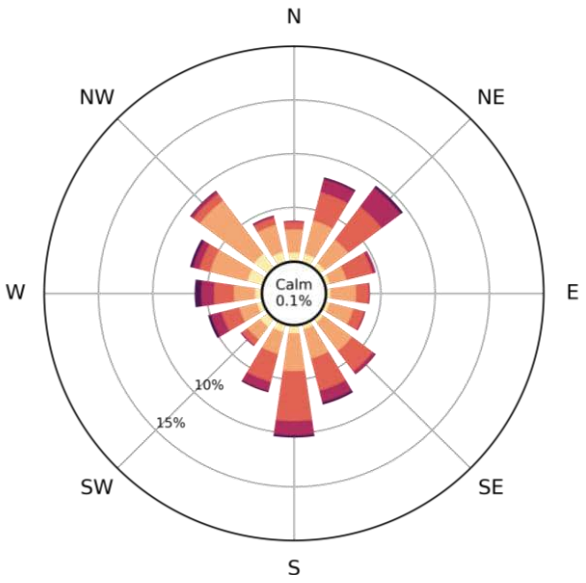


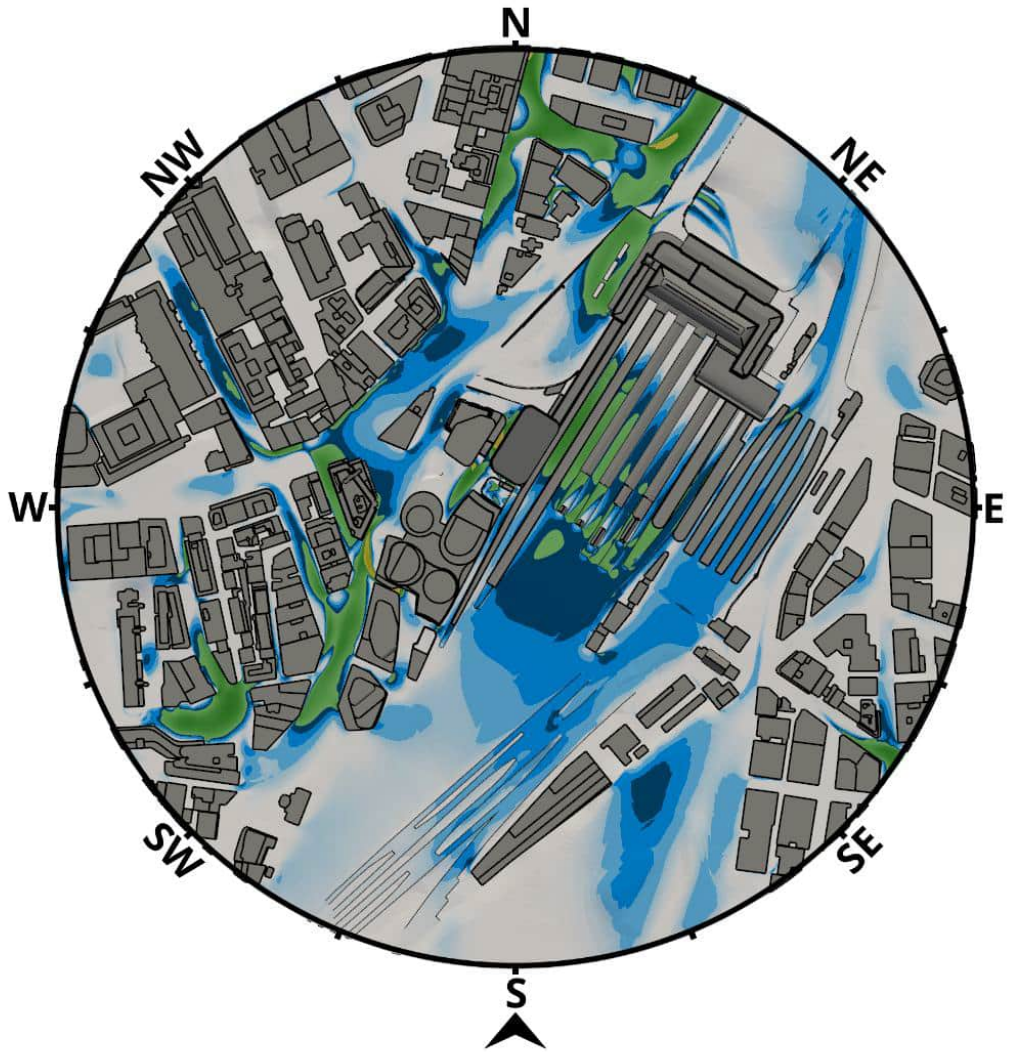


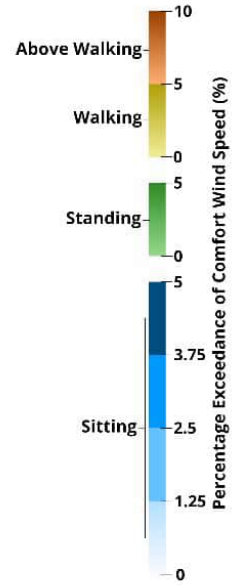


COMFORT CRITERIA - SOUTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

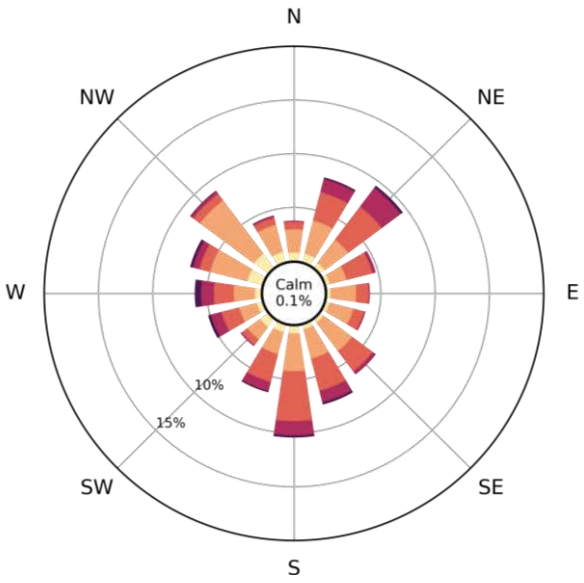


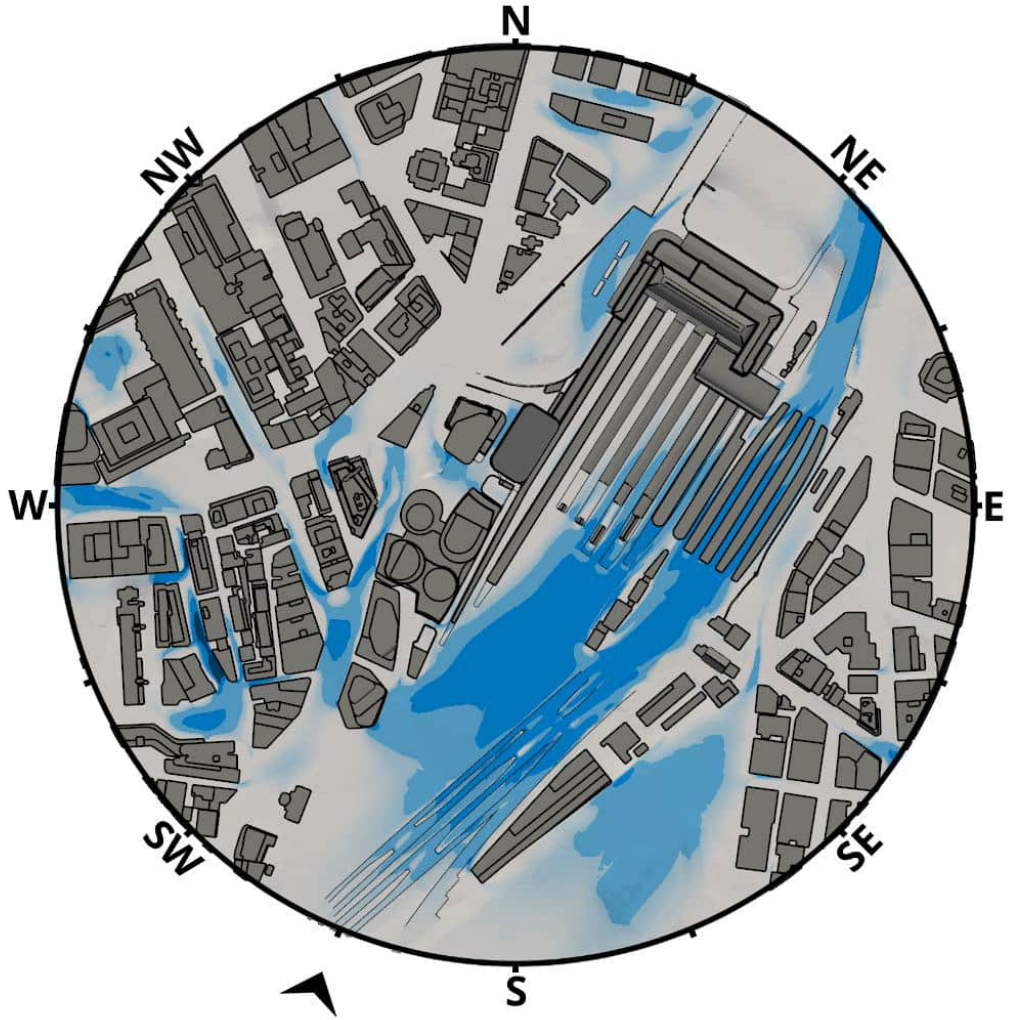


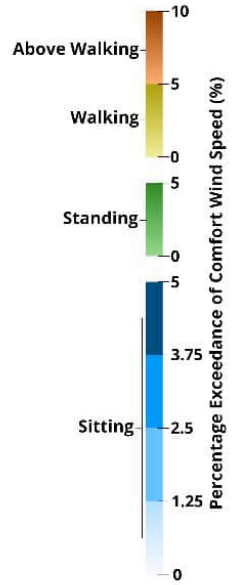


COMFORT CRITERIA - SOUTH-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

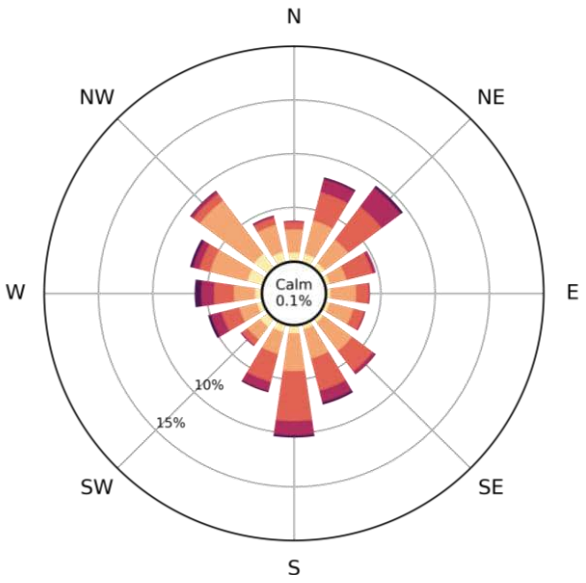


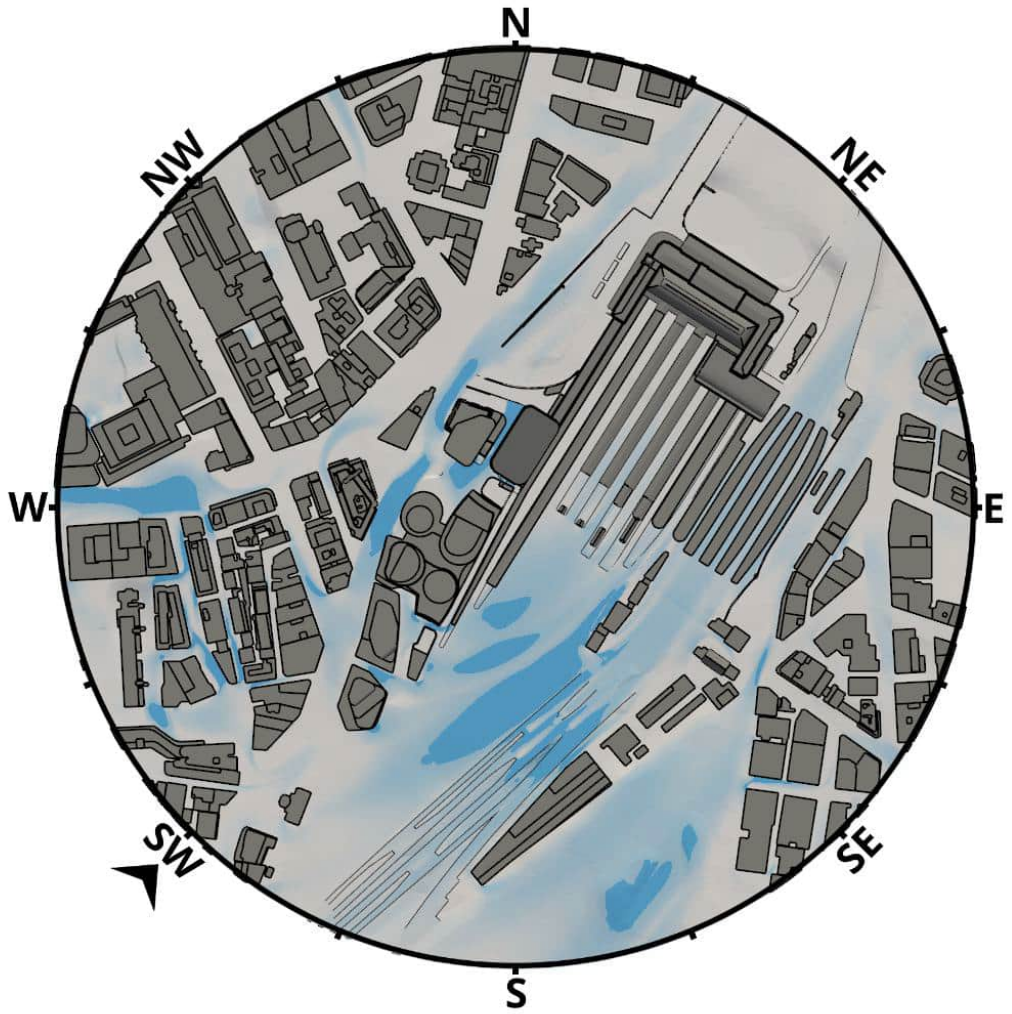


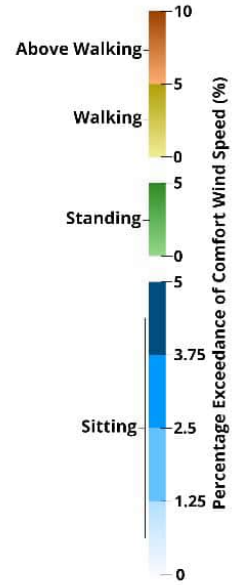


COMFORT CRITERIA - SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

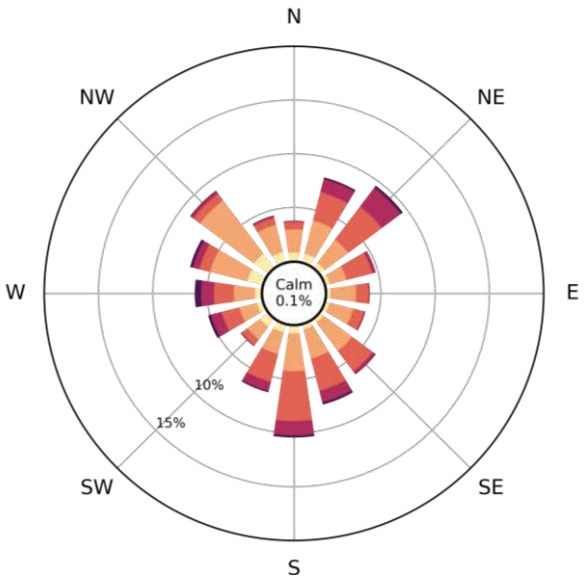


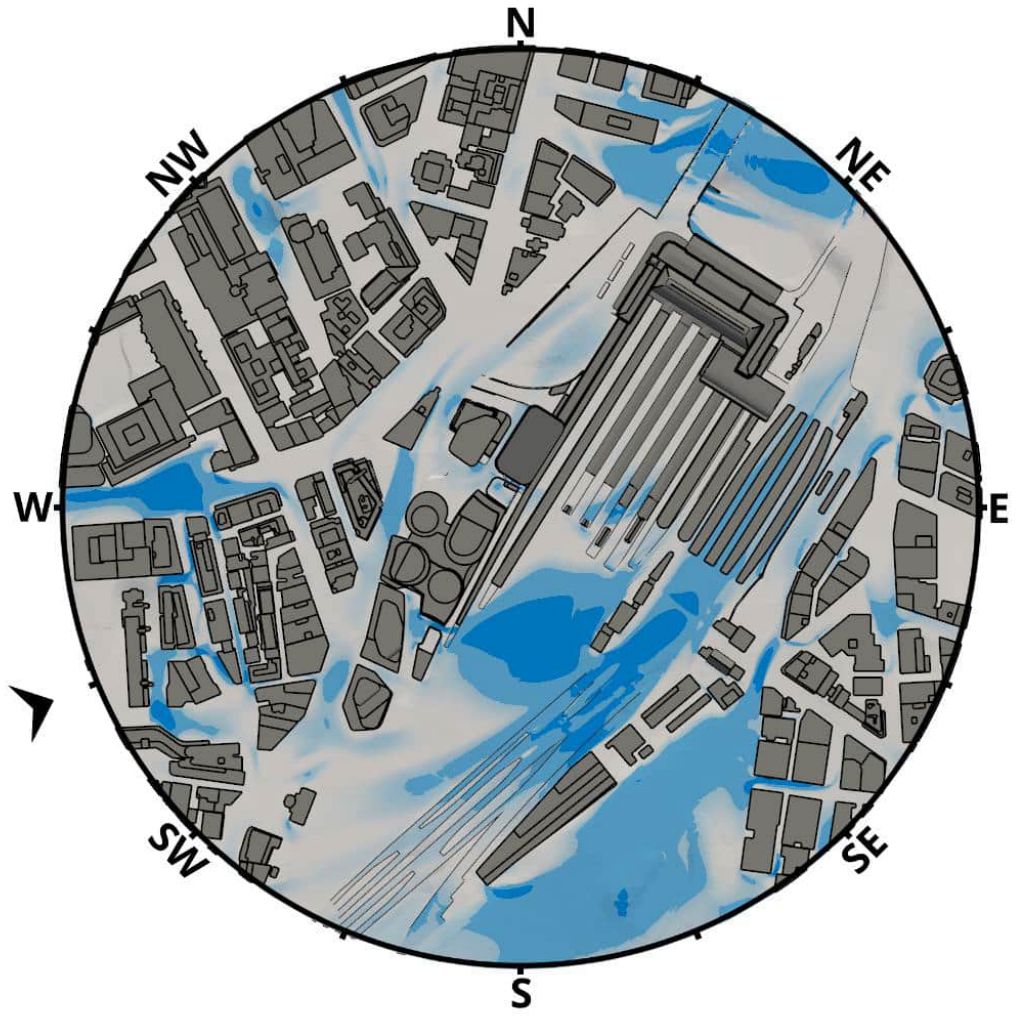


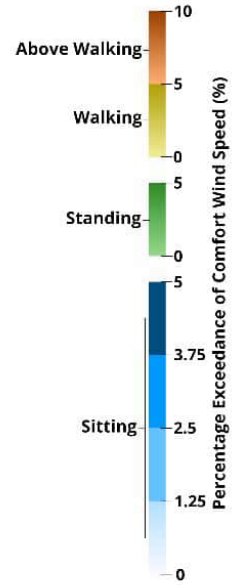


COMFORT CRITERIA - WEST-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

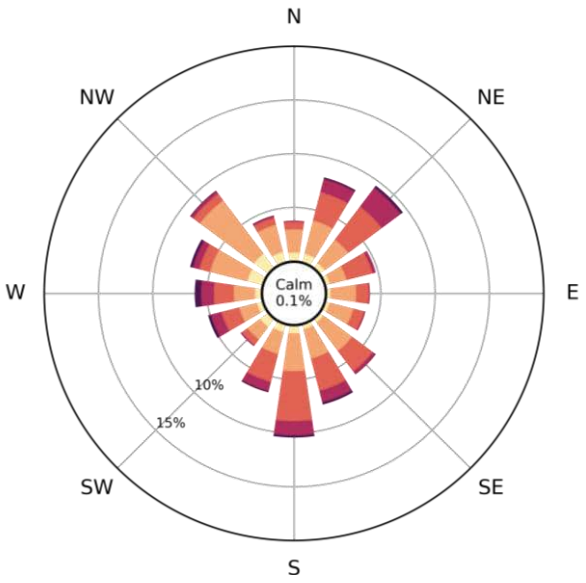


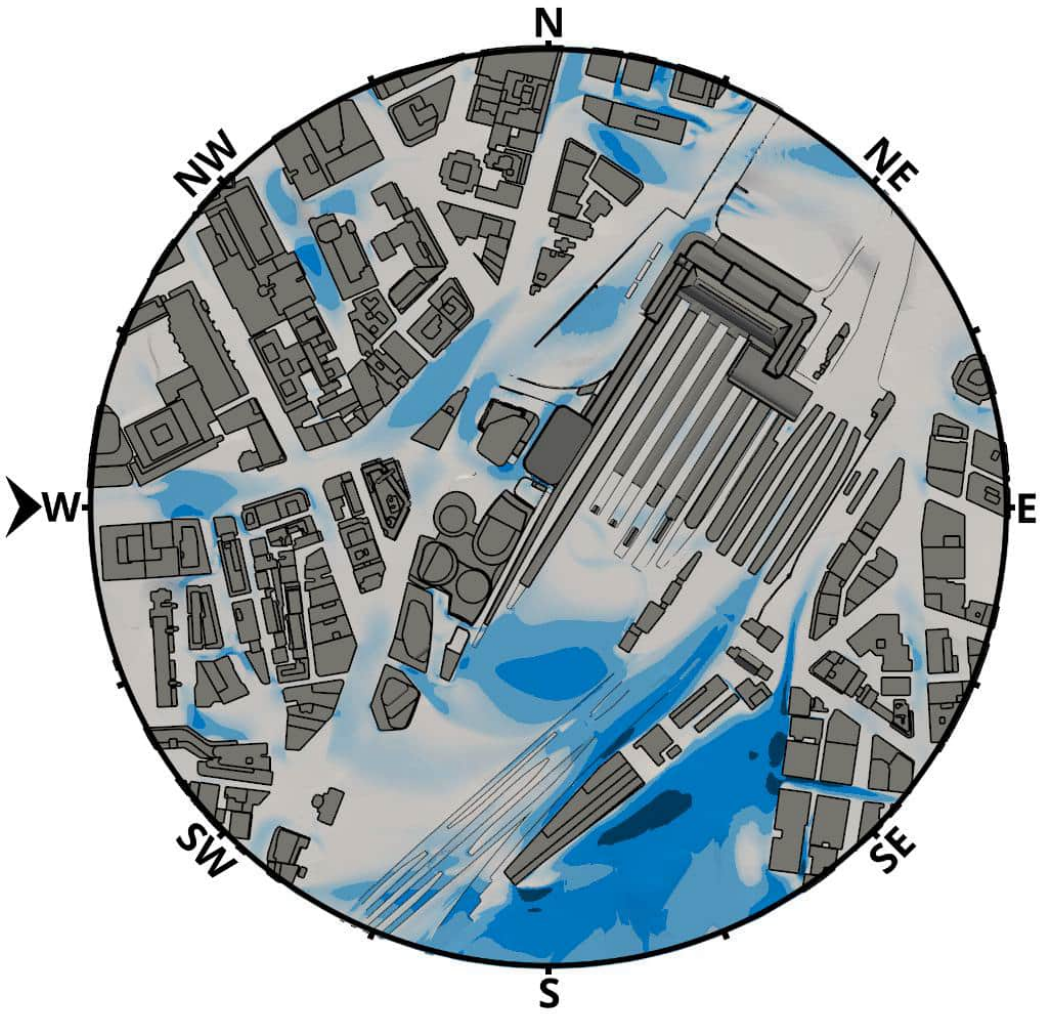


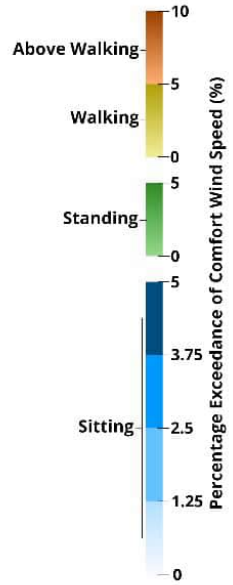


COMFORT CRITERIA - WEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

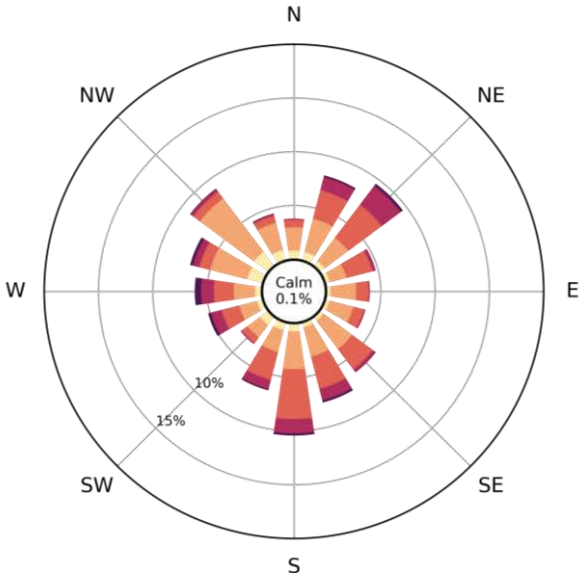


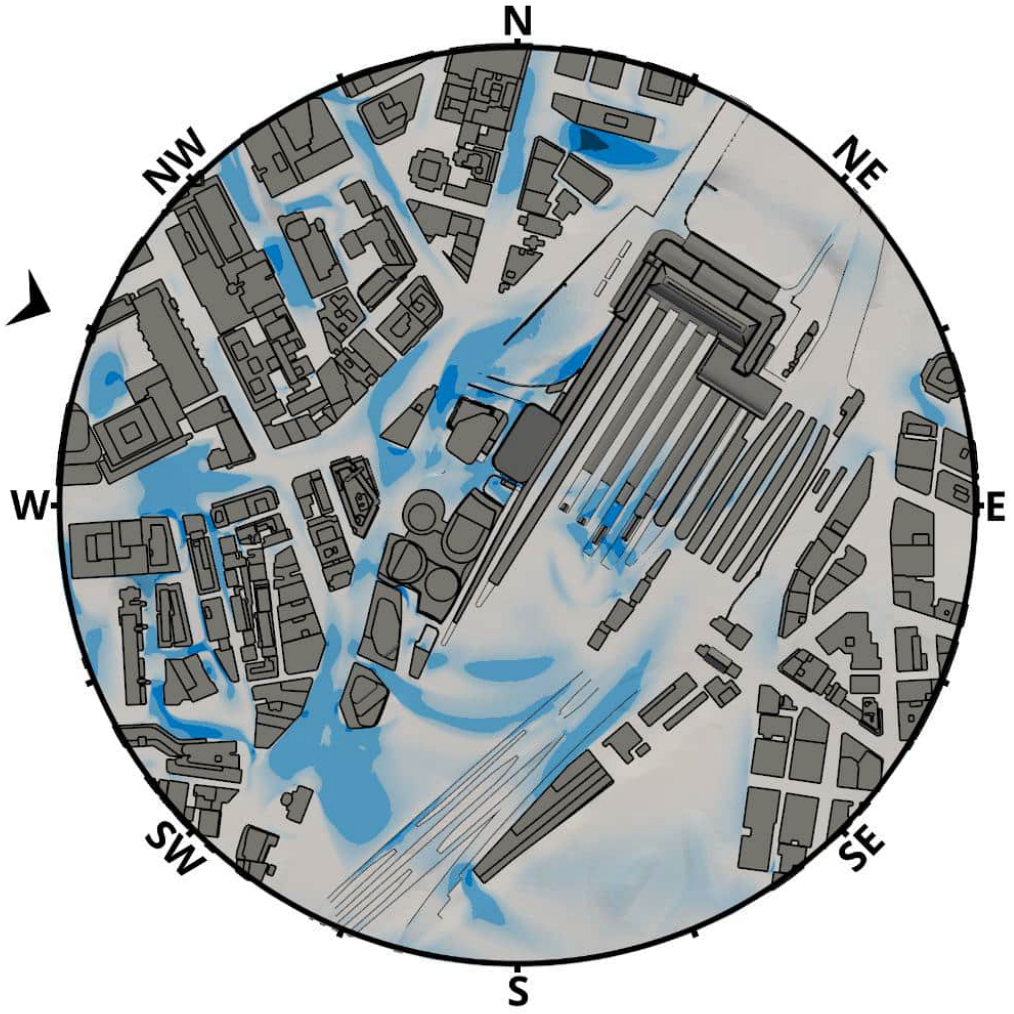


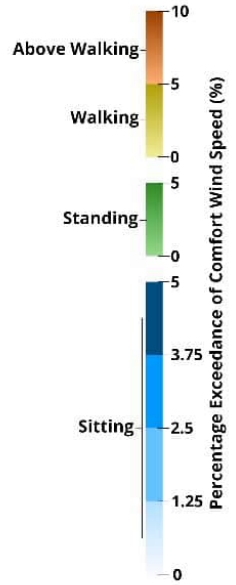


COMFORT CRITERIA - WEST-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

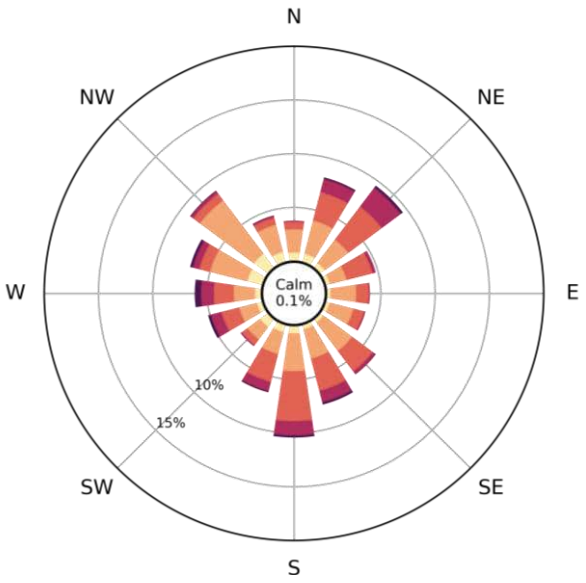


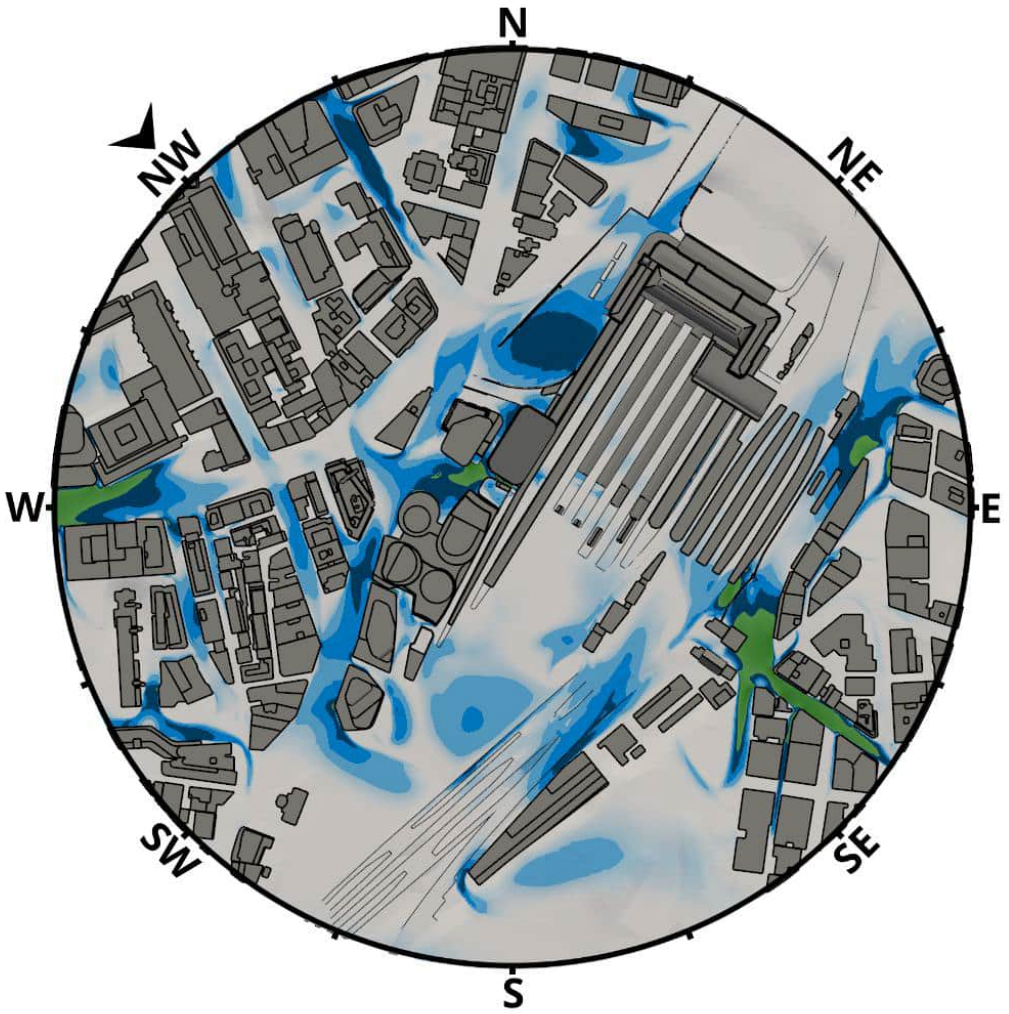


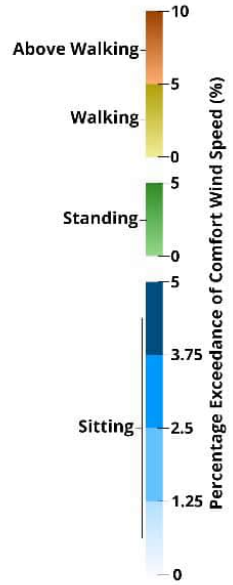


COMFORT CRITERIA - NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

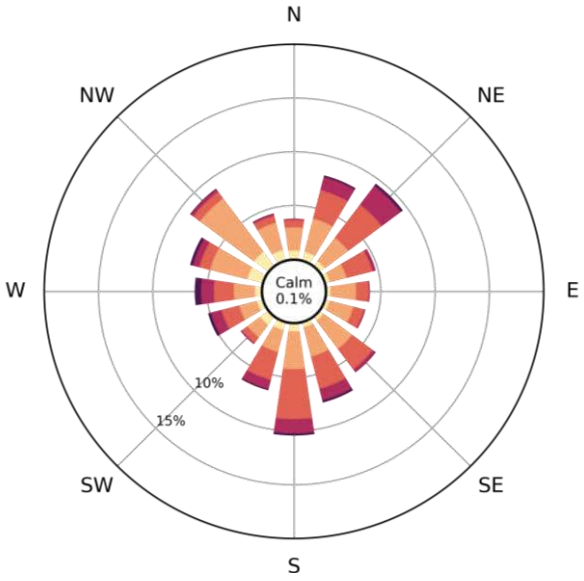


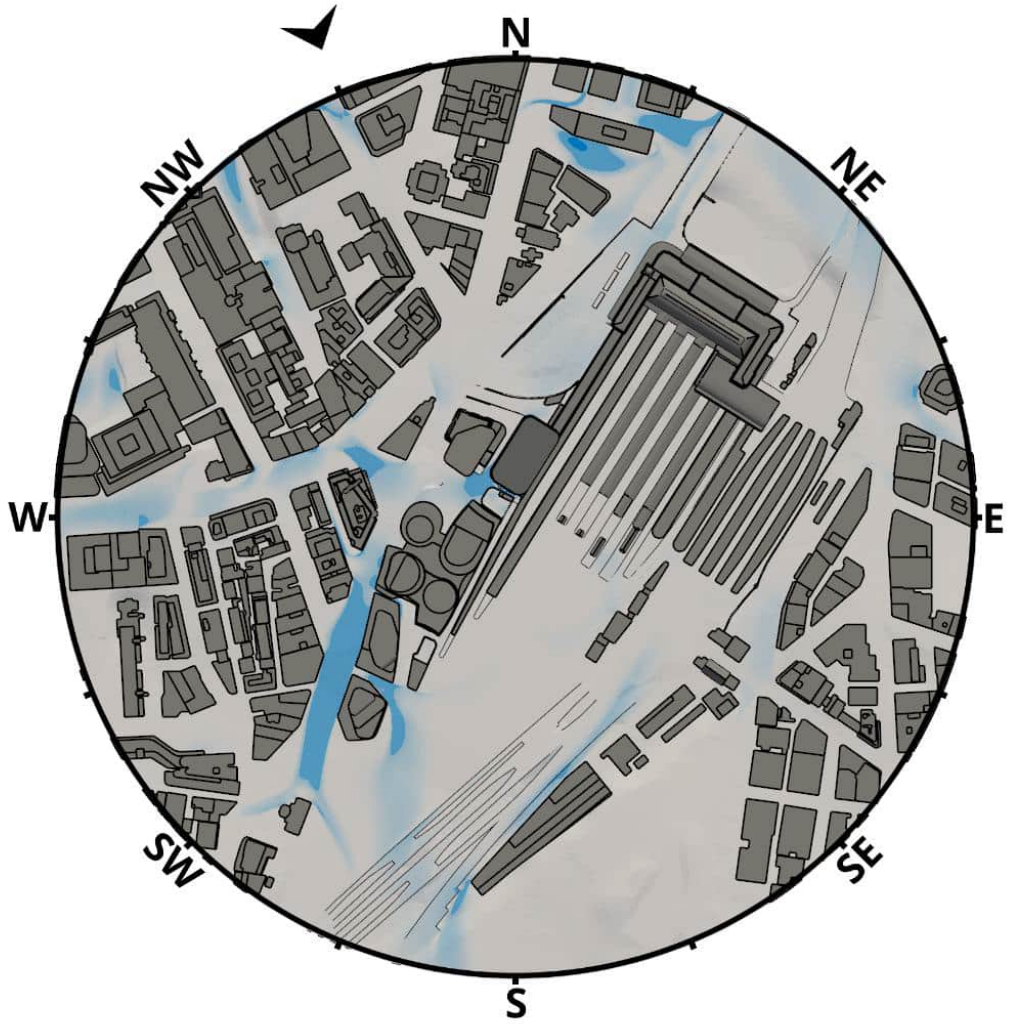


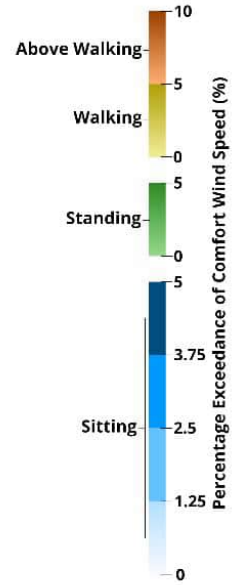


COMFORT CRITERIA - NORTH-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline



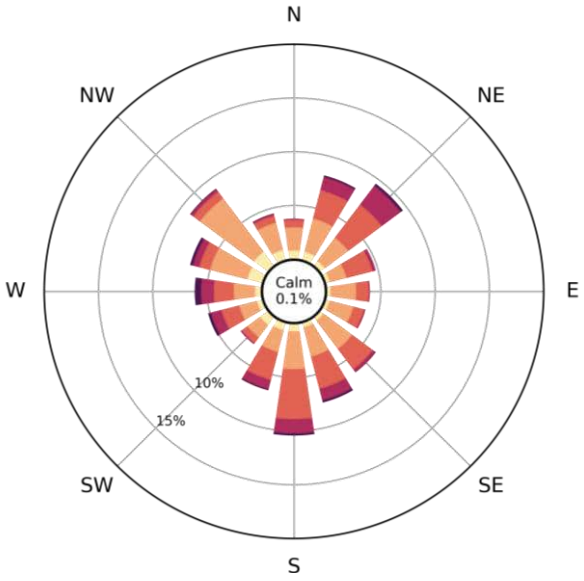


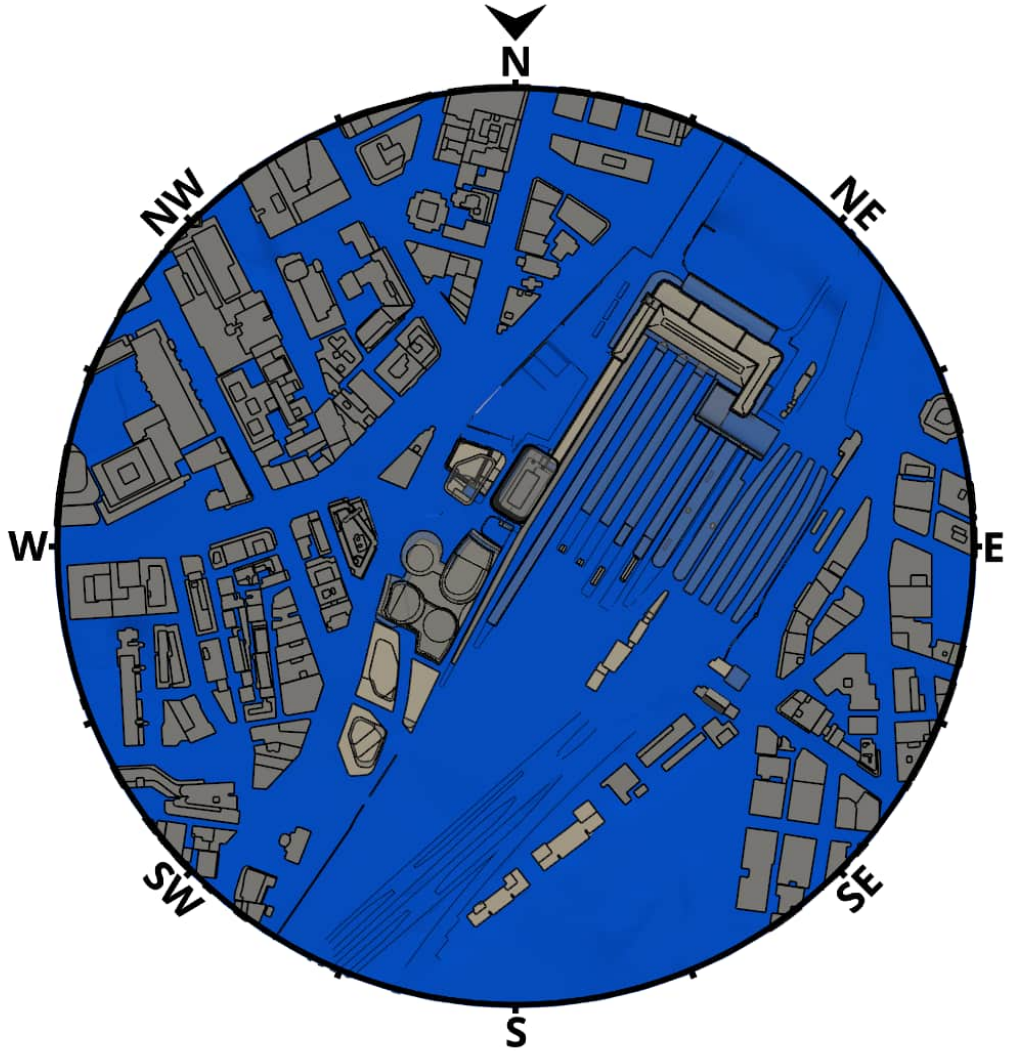


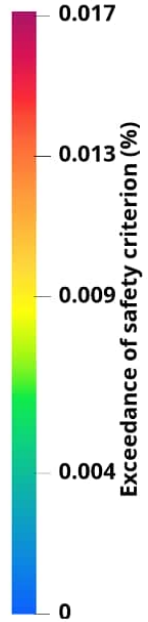
Option 2 - Directional Contributions - Safety

SAFETY CRITERIA - NORTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

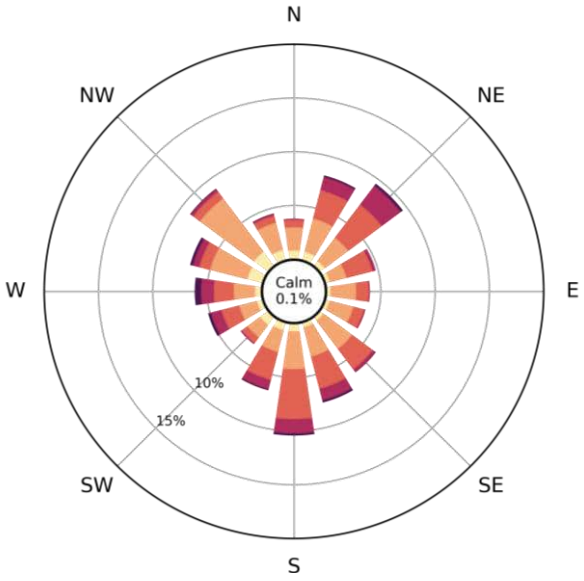


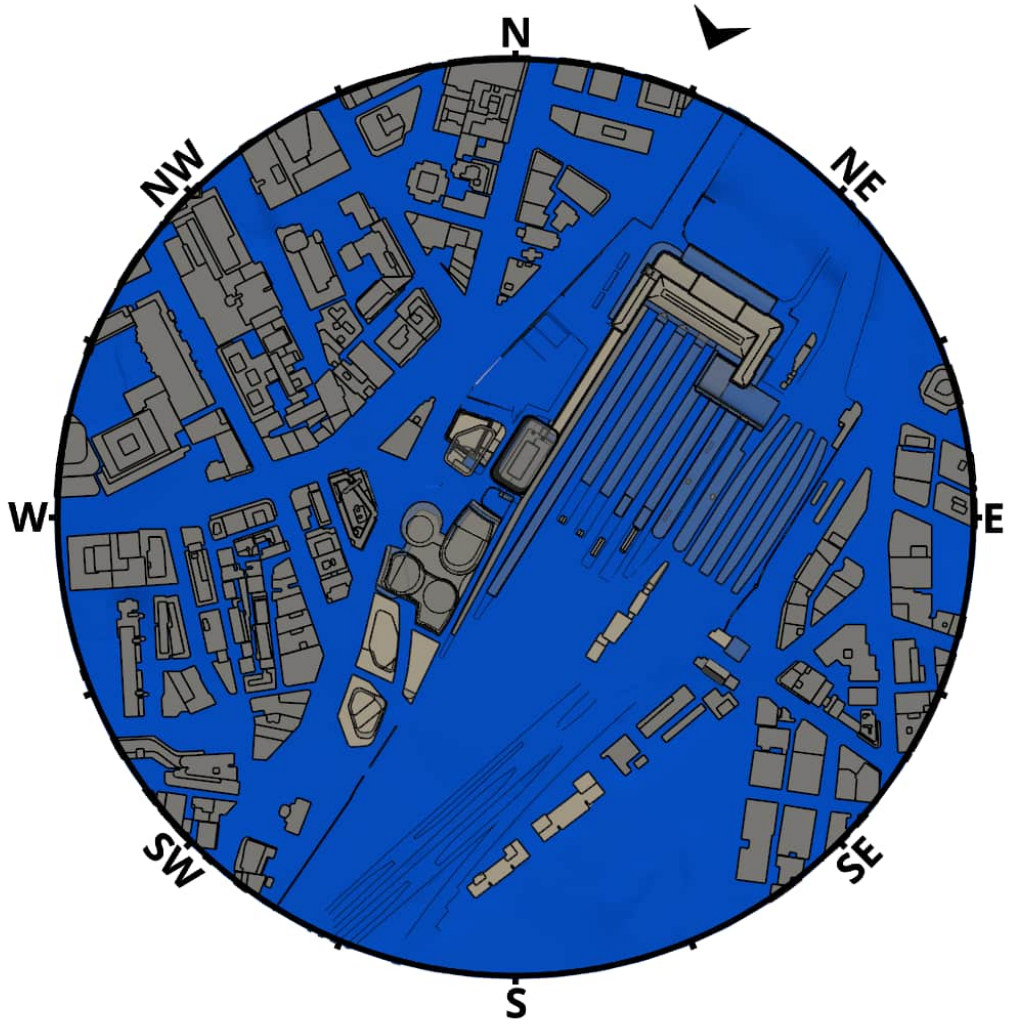


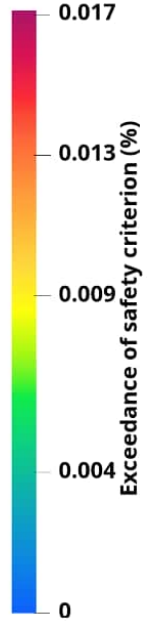


SAFETY CRITERIA - NORTH-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

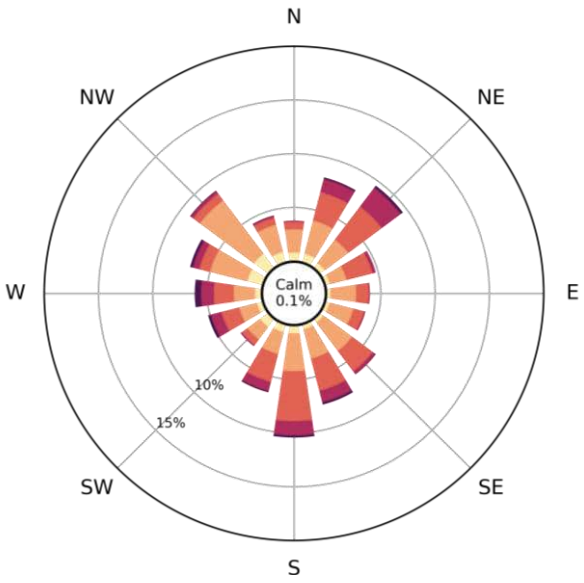


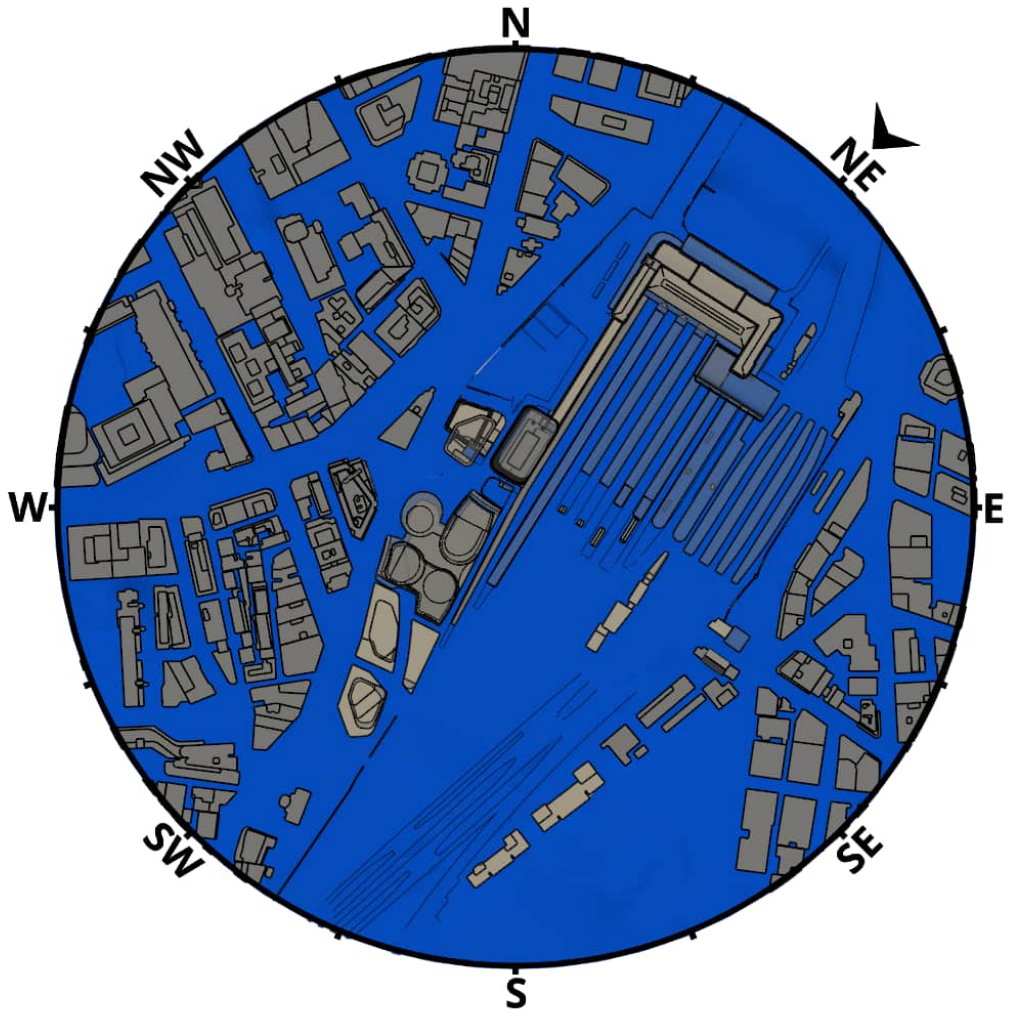


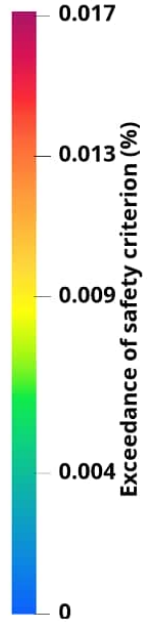


SAFETY CRITERIA - NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

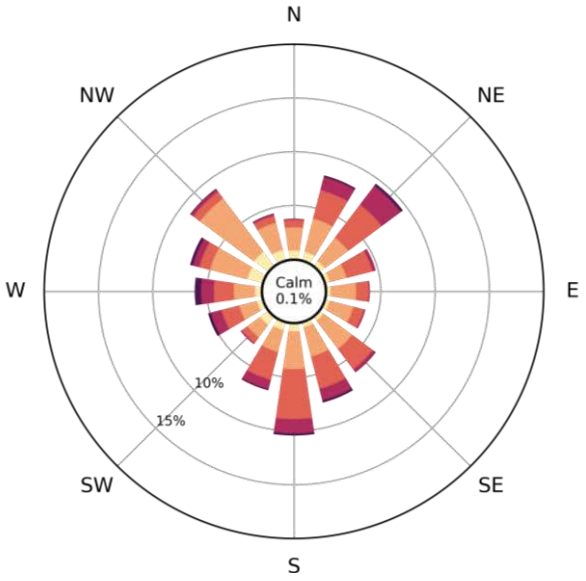


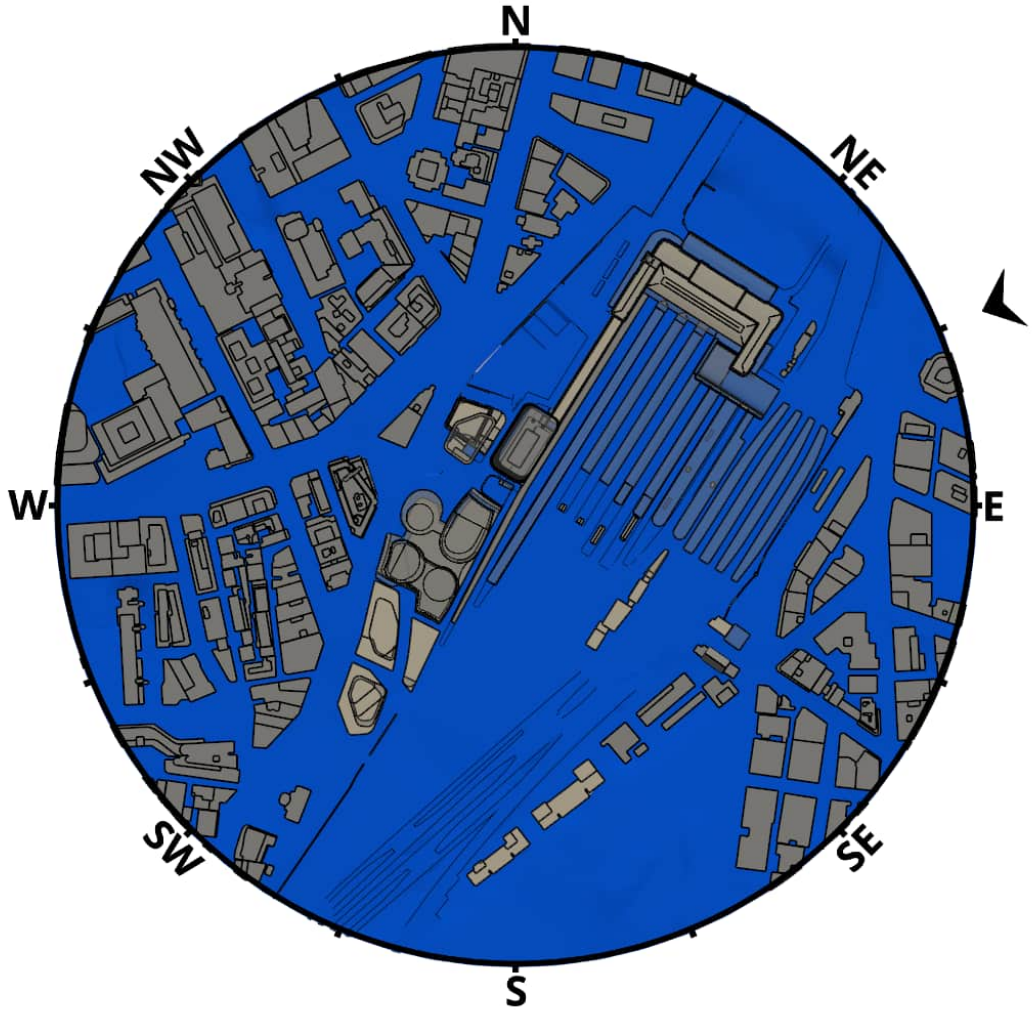


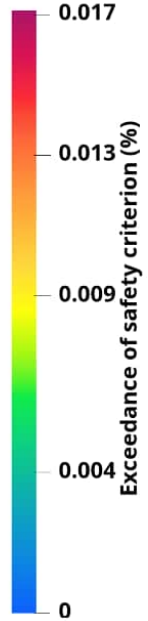


SAFETY CRITERIA - EAST-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

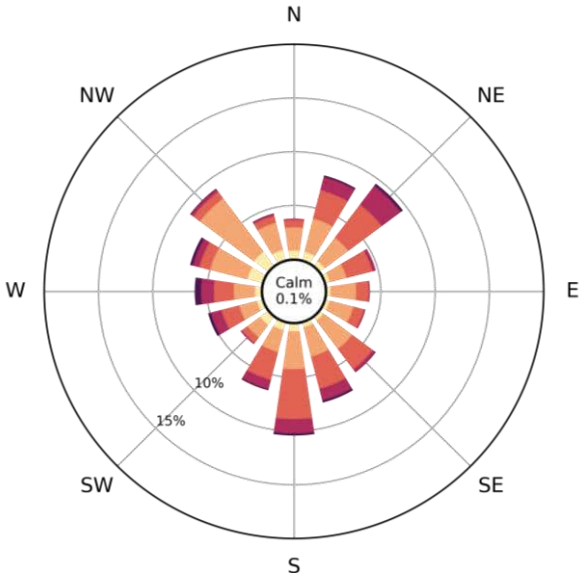


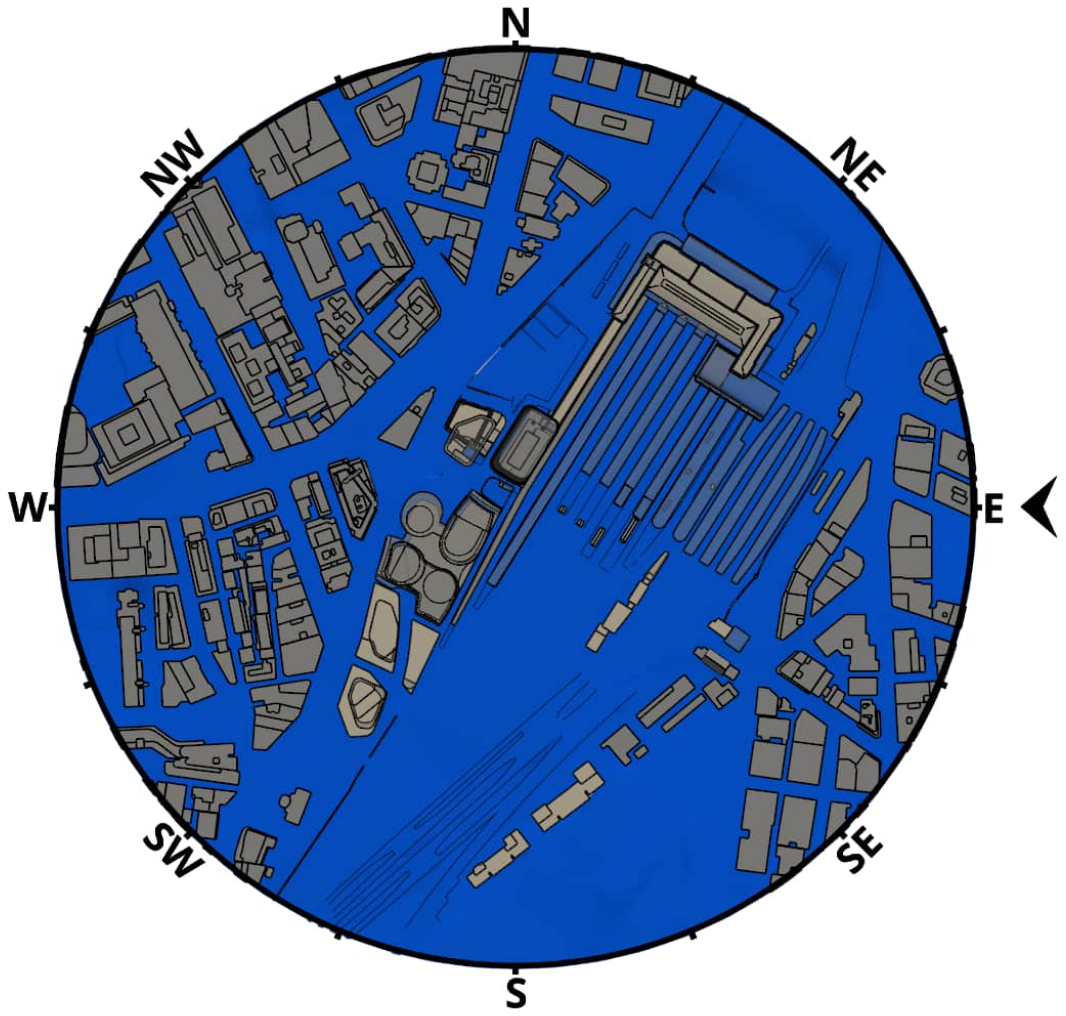


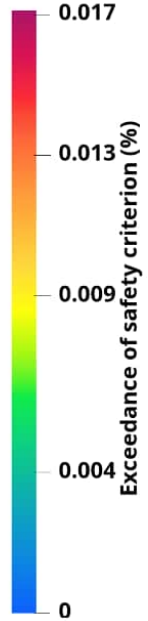


SAFETY CRITERIA - EAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

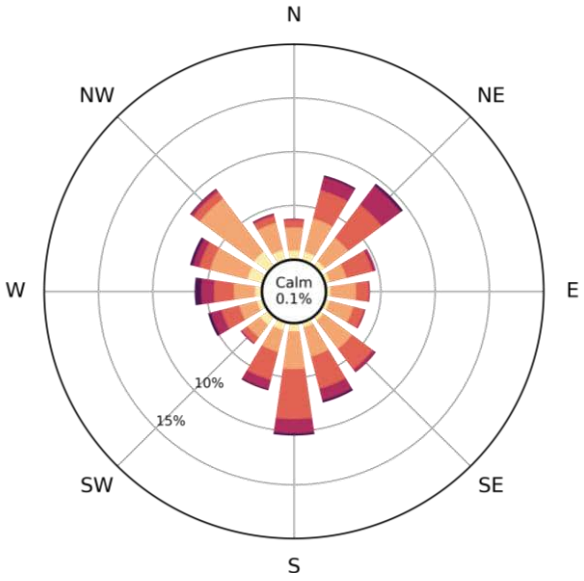


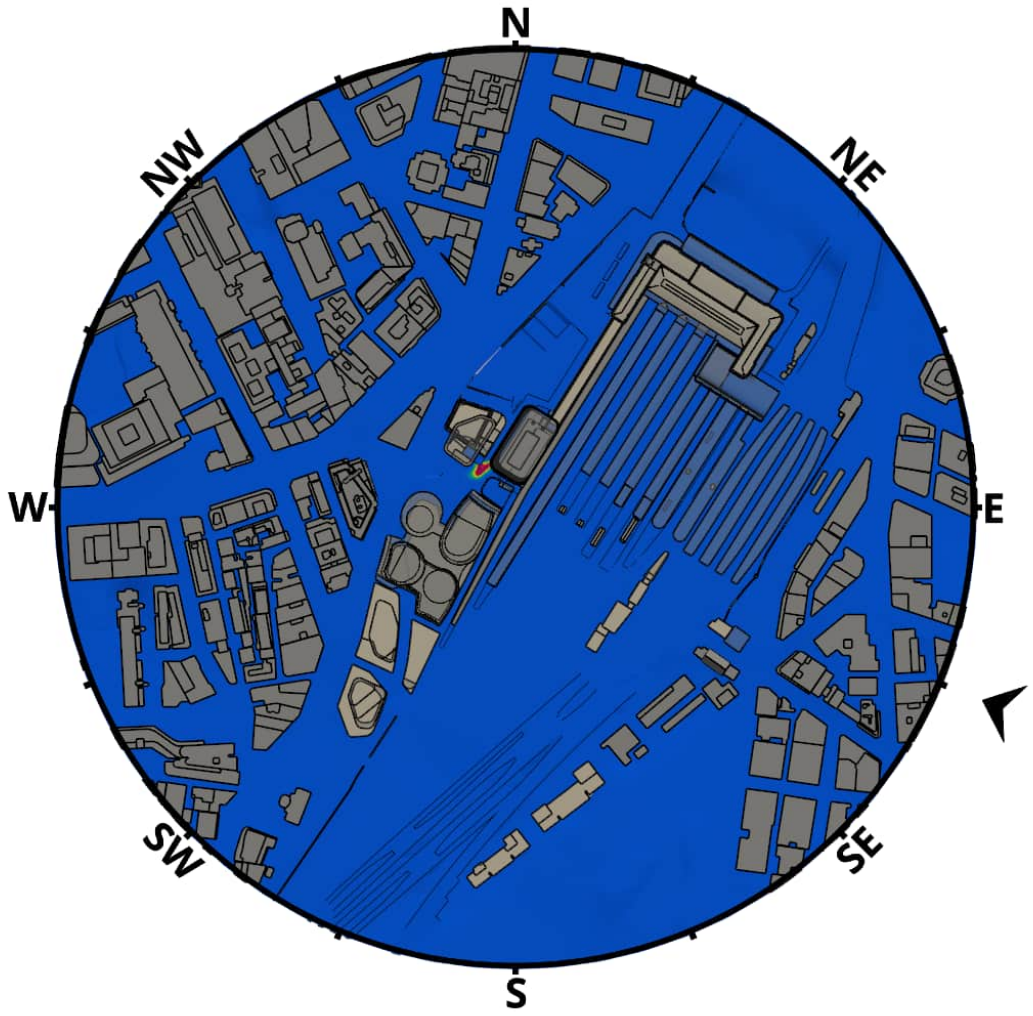


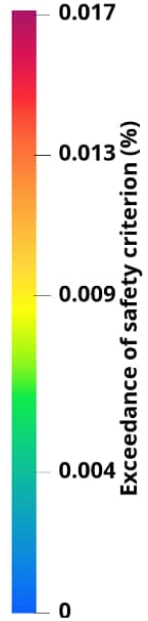


SAFETY CRITERIA - EAST-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

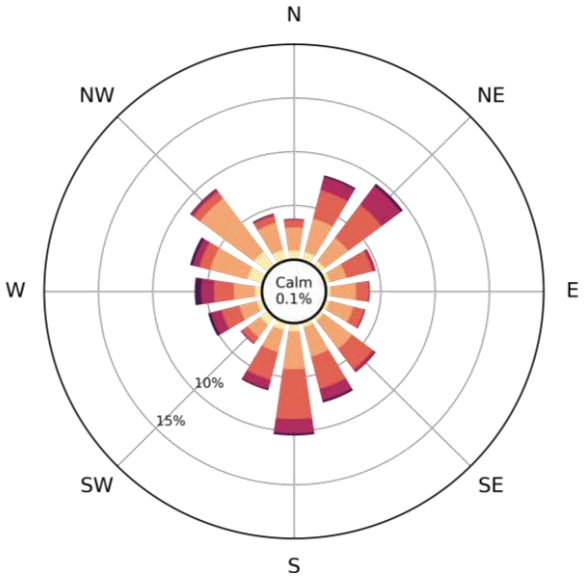


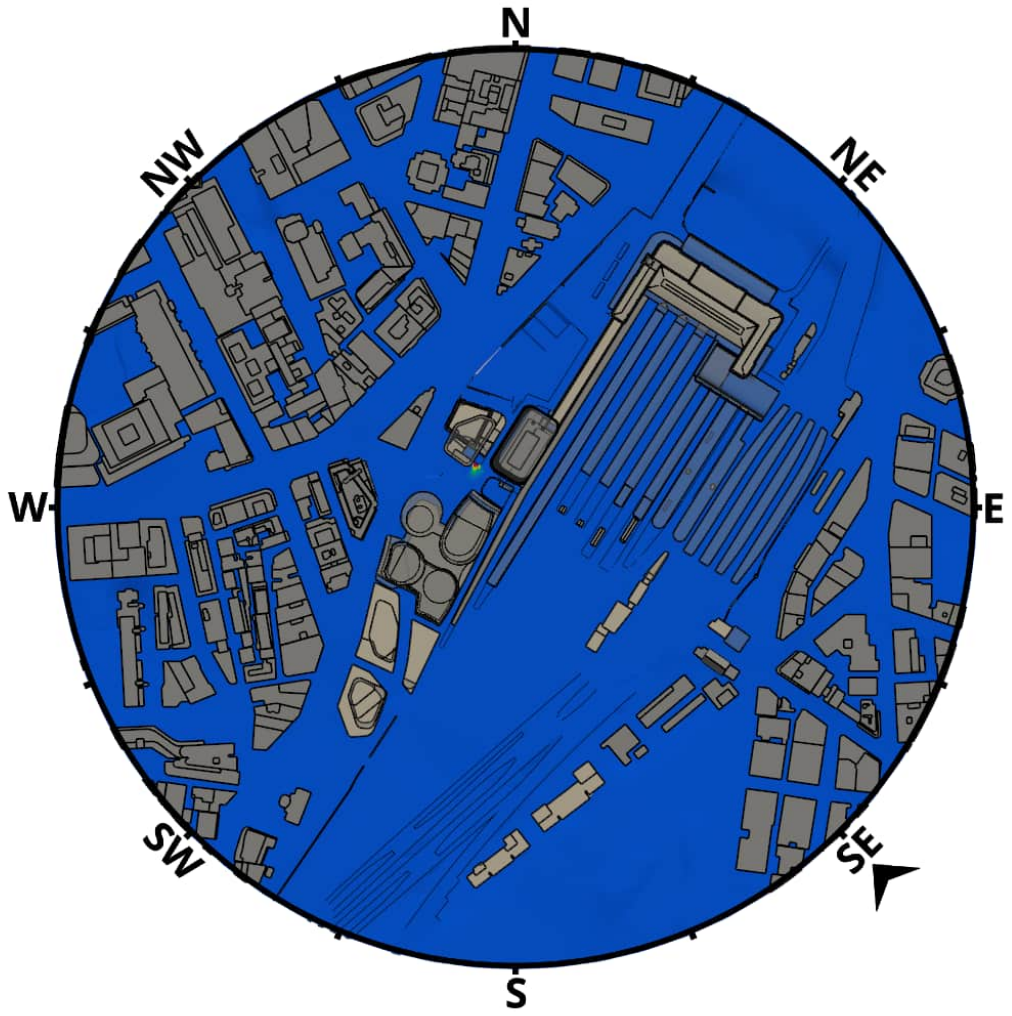


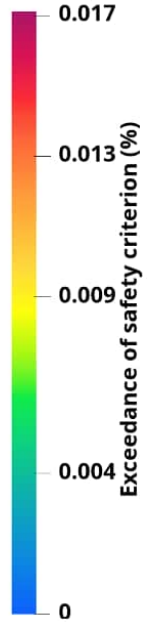


SAFETY CRITERIA - SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

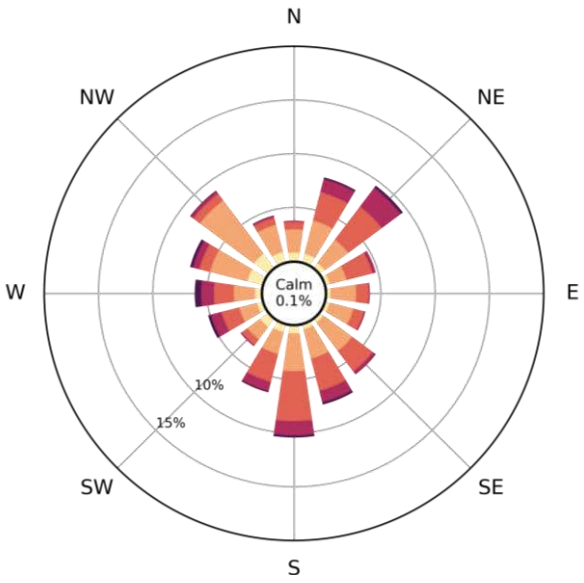


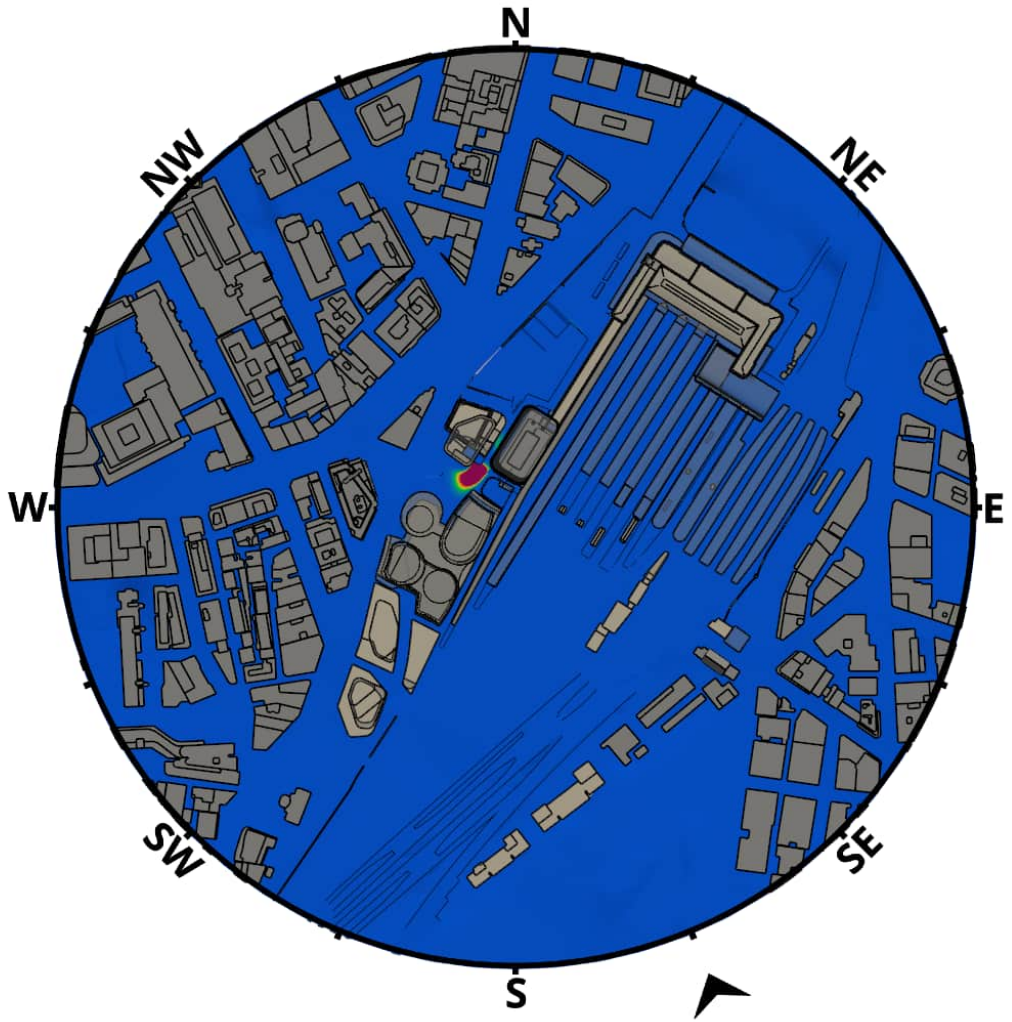


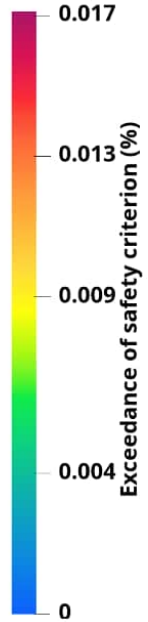


SAFETY CRITERIA - SOUTH-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

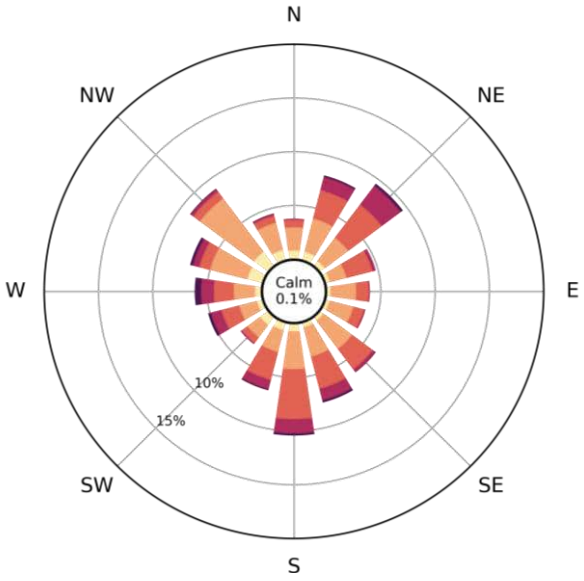


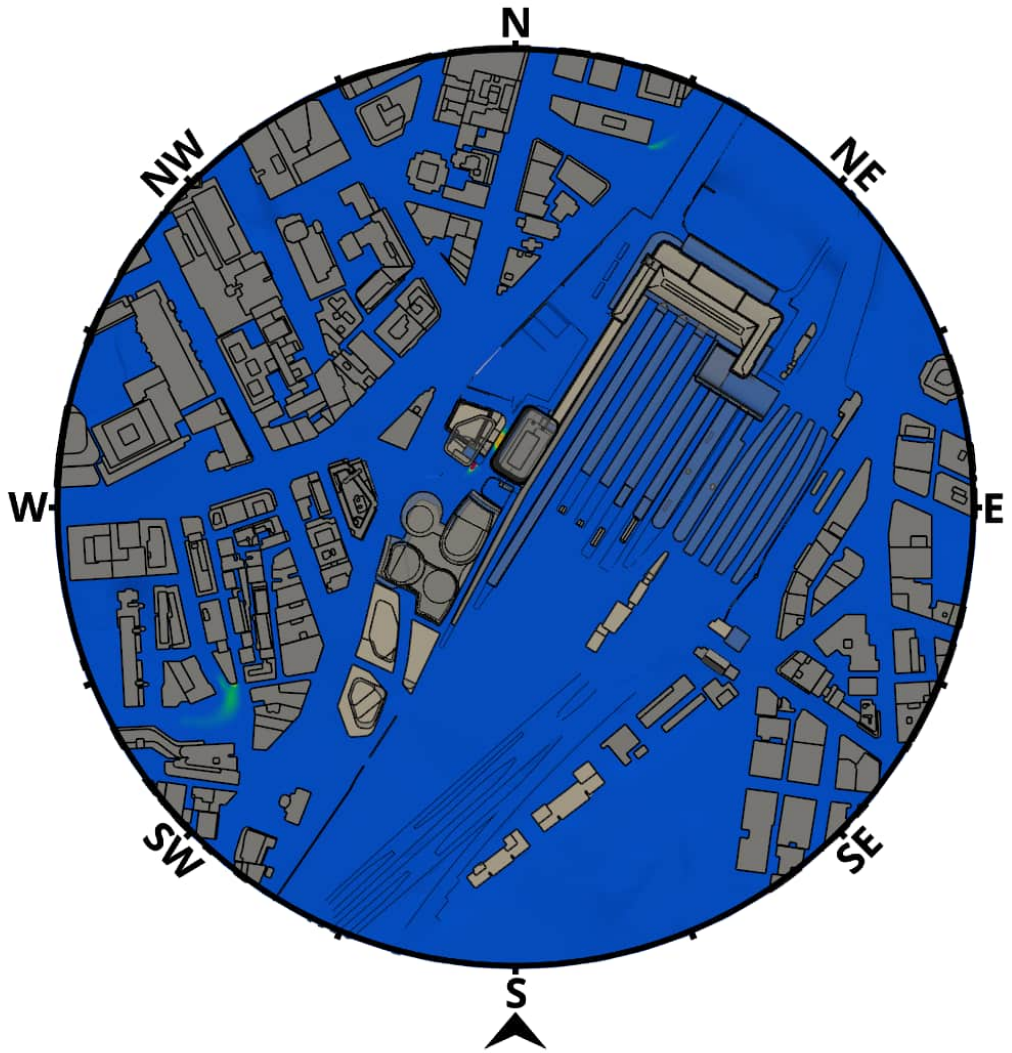


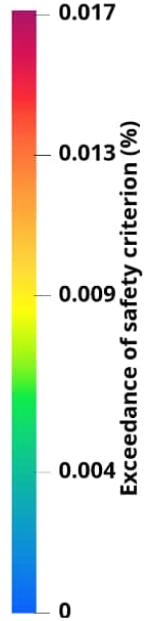


SAFETY CRITERIA - SOUTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

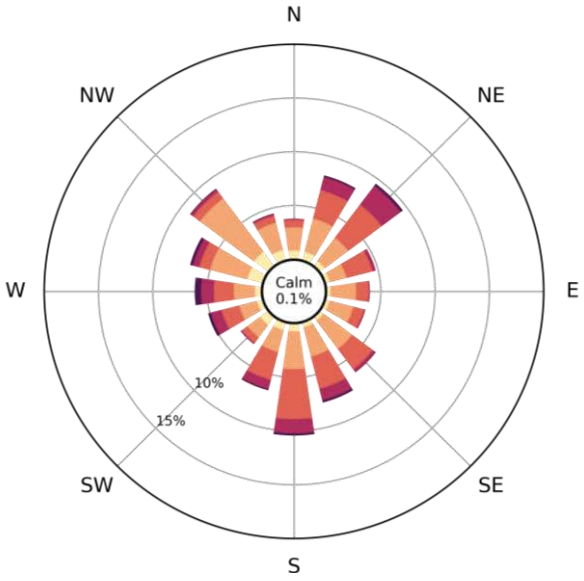


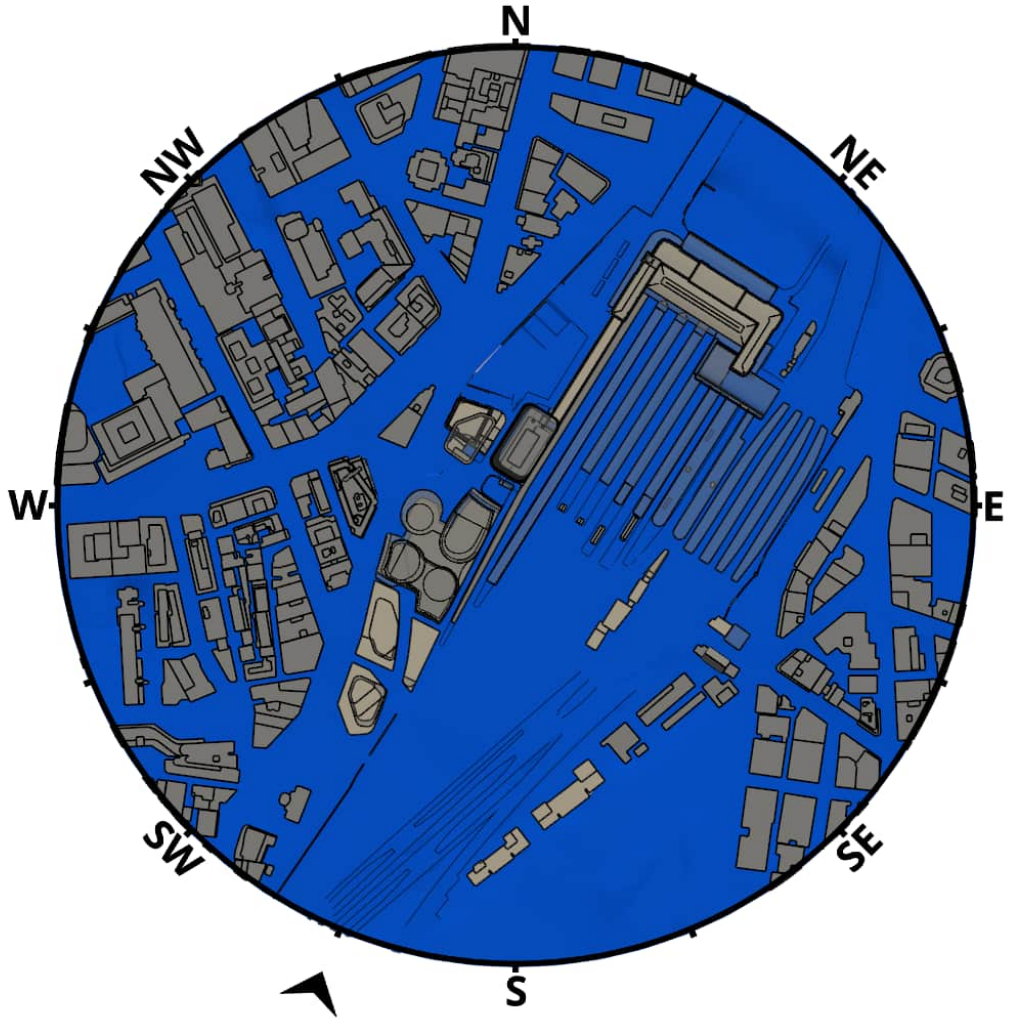


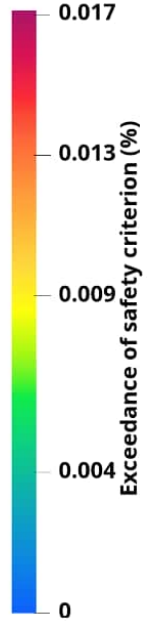


SAFETY CRITERIA - SOUTH-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

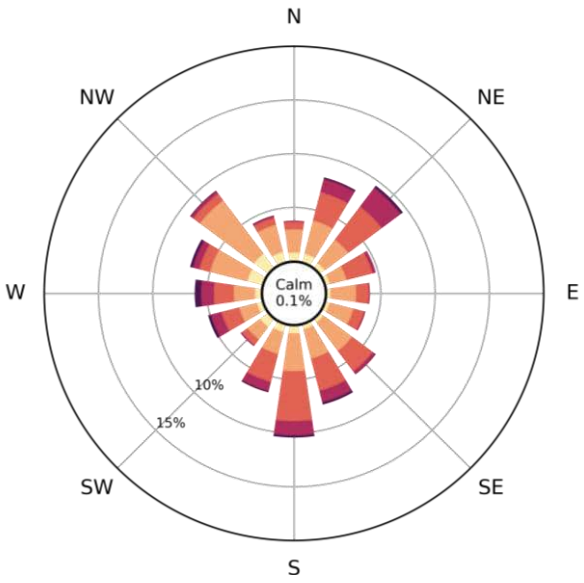


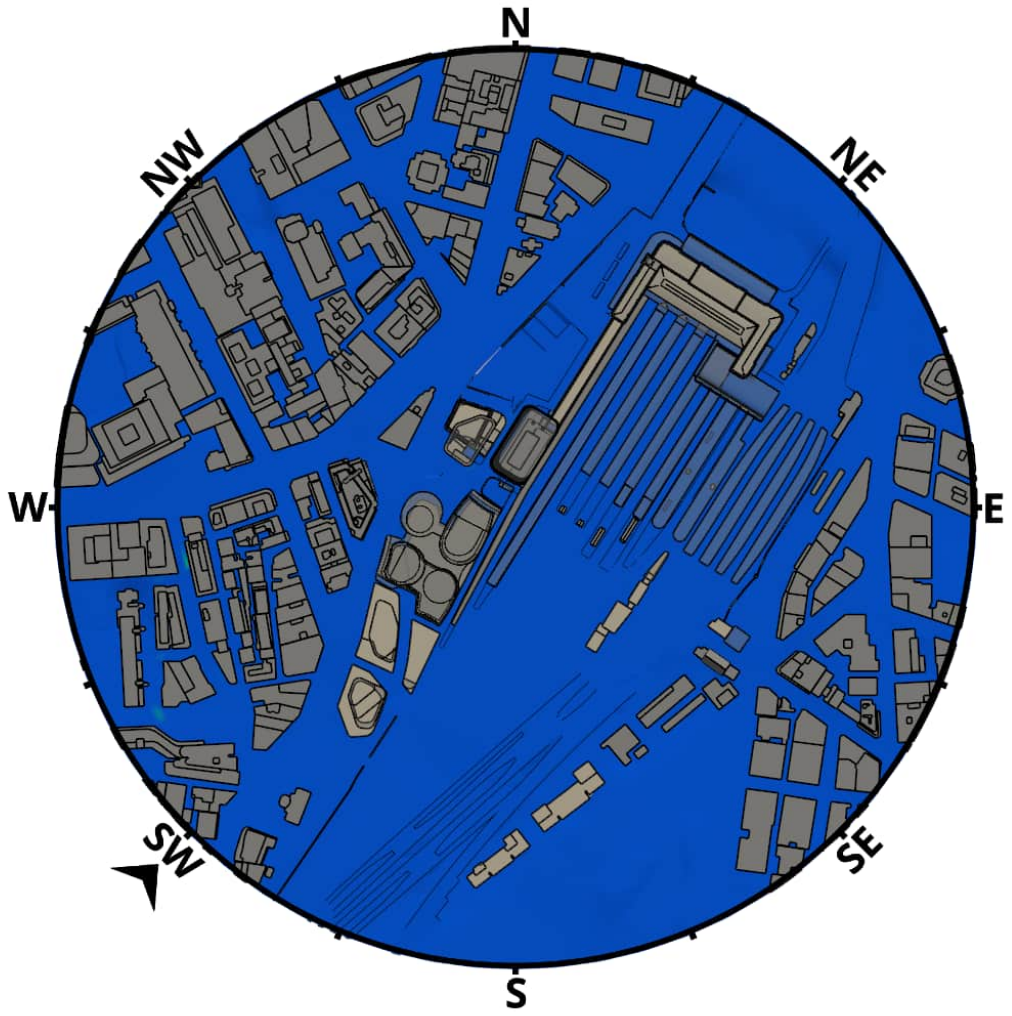


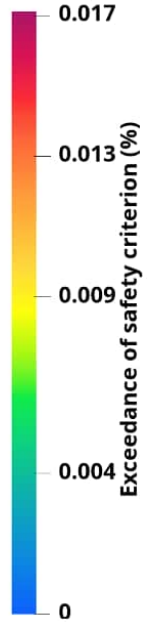


SAFETY CRITERIA - SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

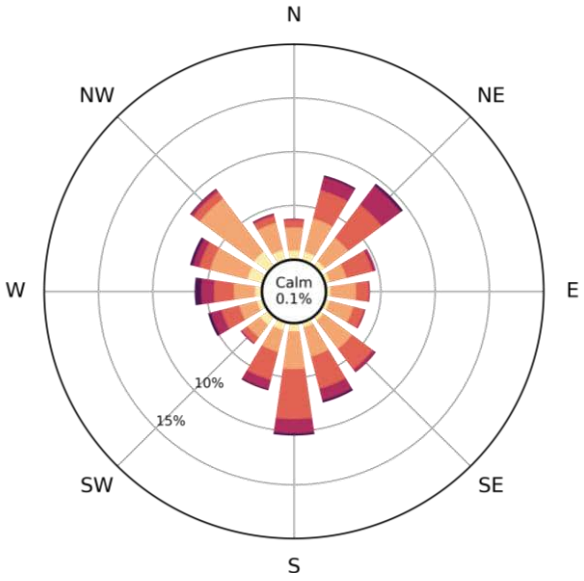


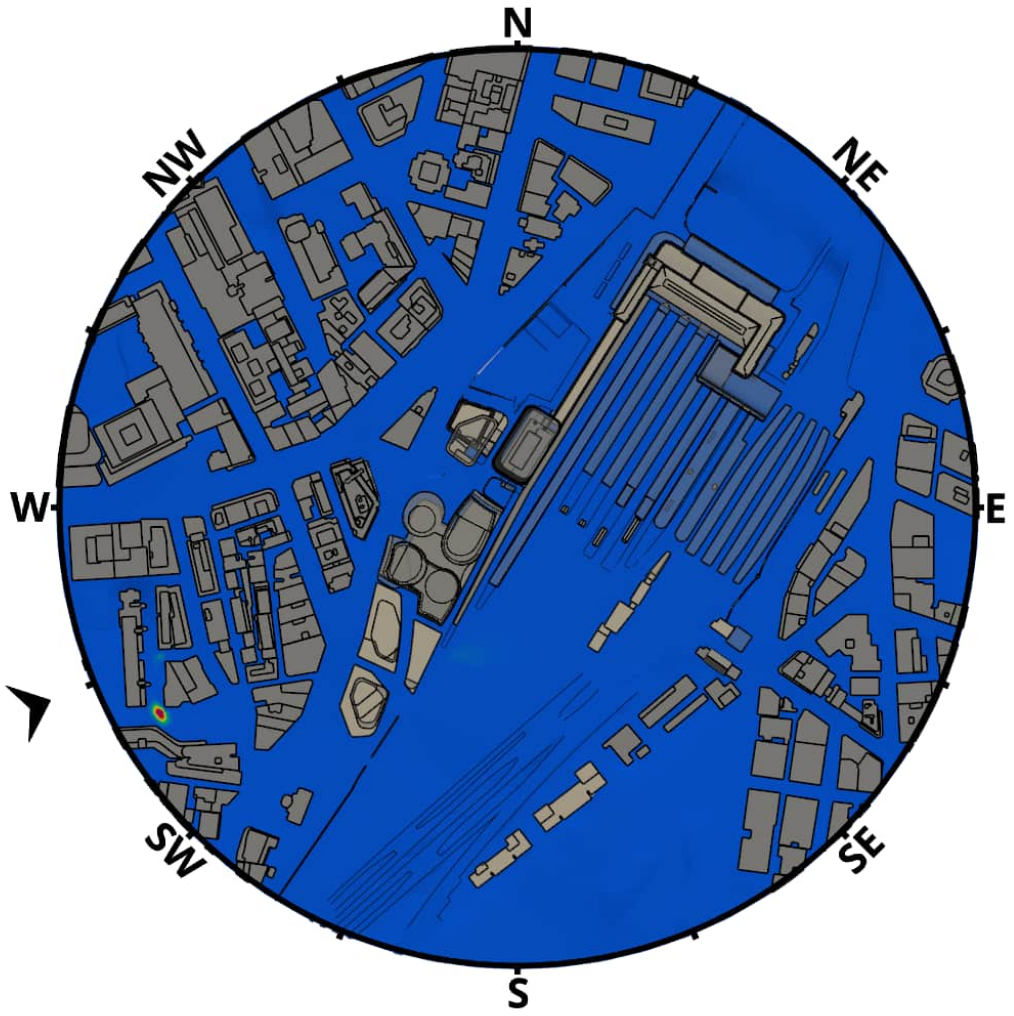


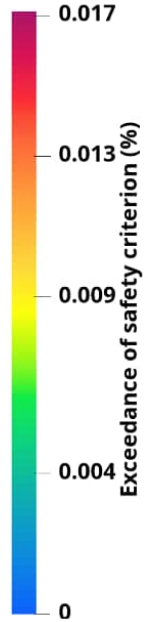


SAFETY CRITERIA - WEST-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

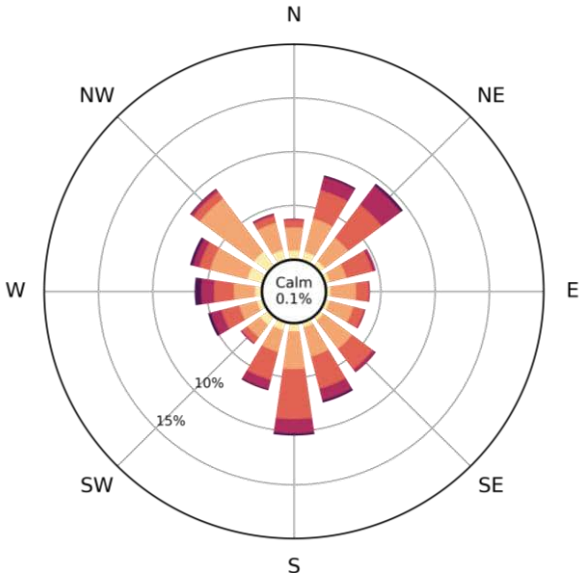


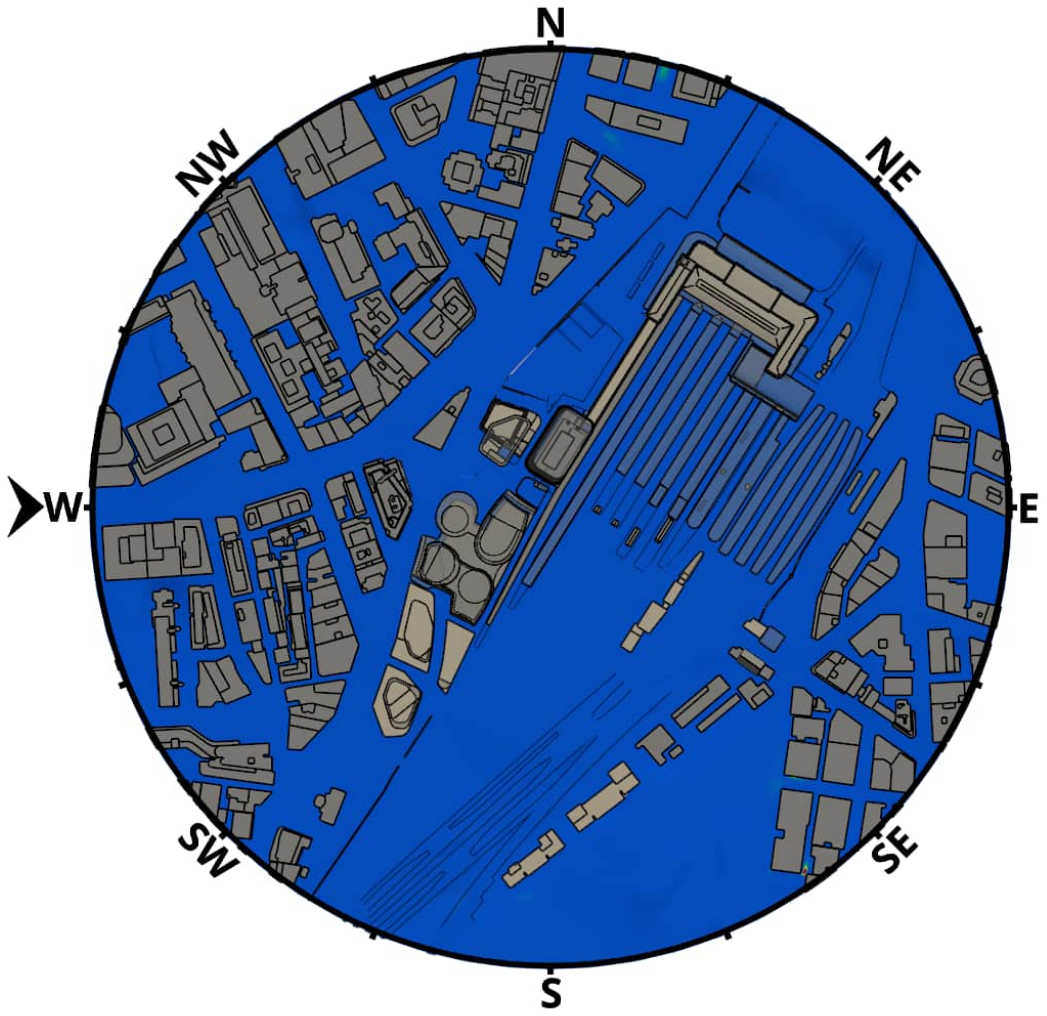


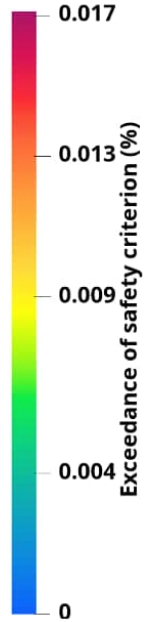


SAFETY CRITERIA - WEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

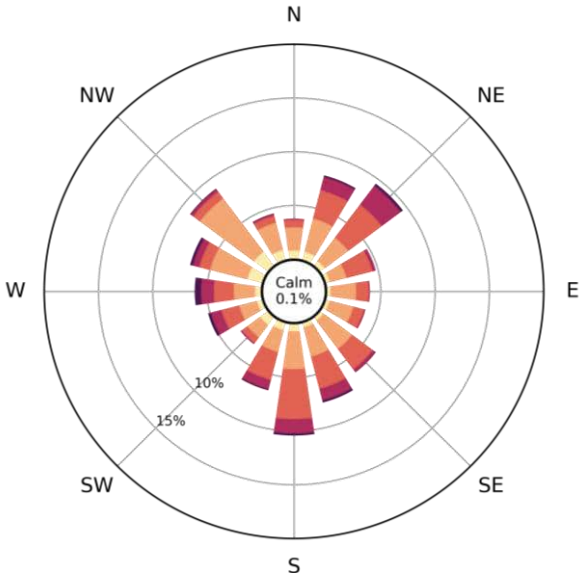


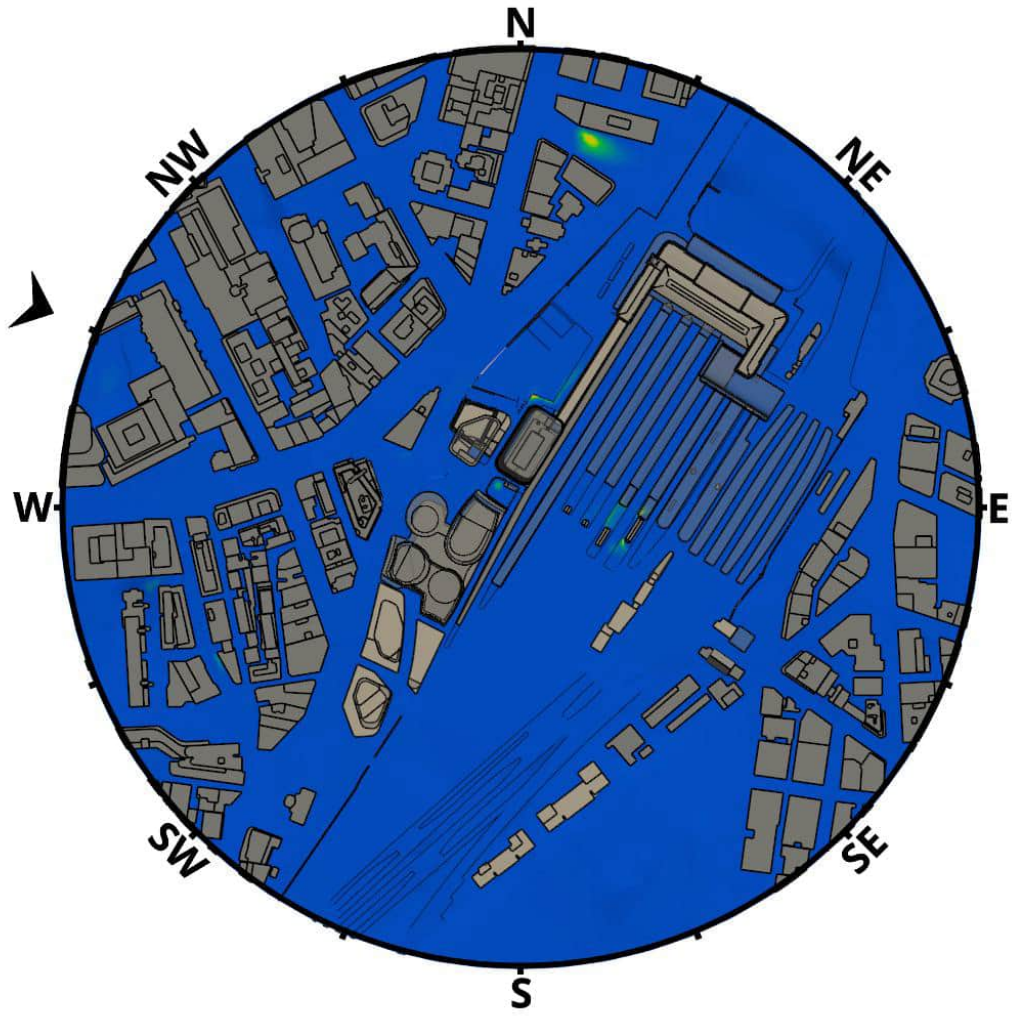


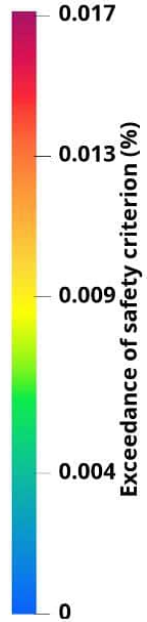


SAFETY CRITERIA - WEST-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

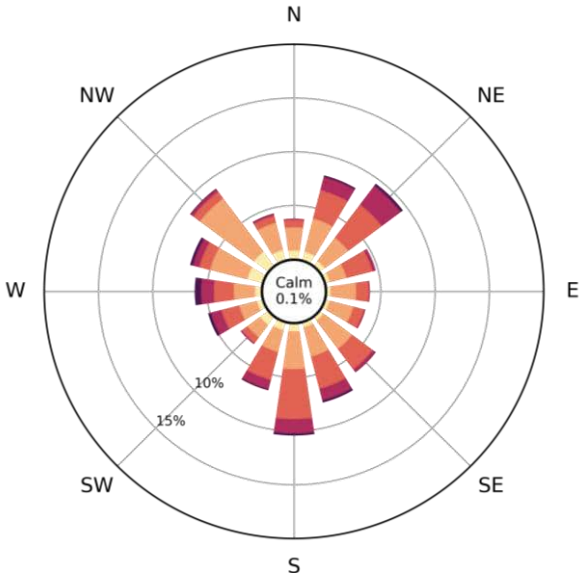


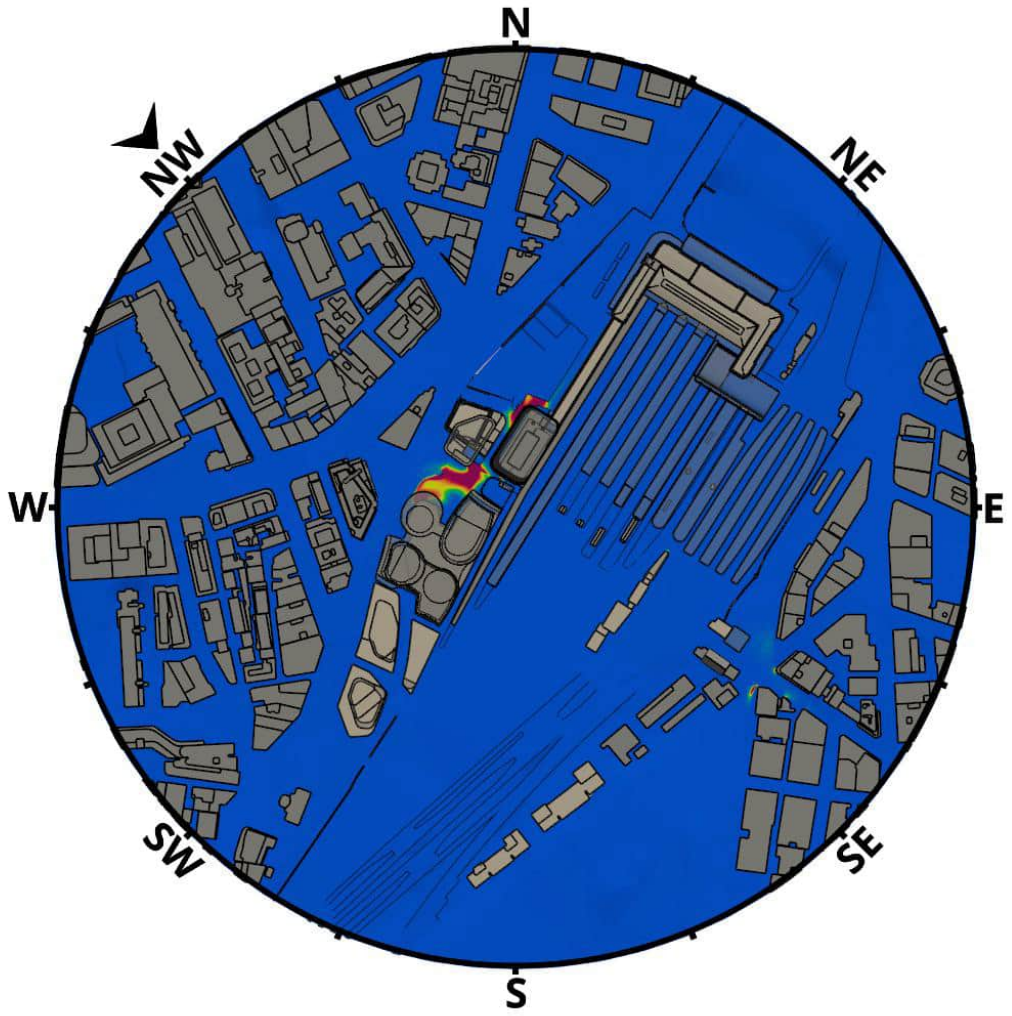


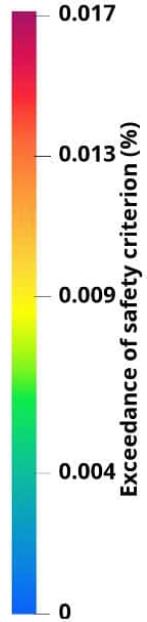


SAFETY CRITERIA - NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

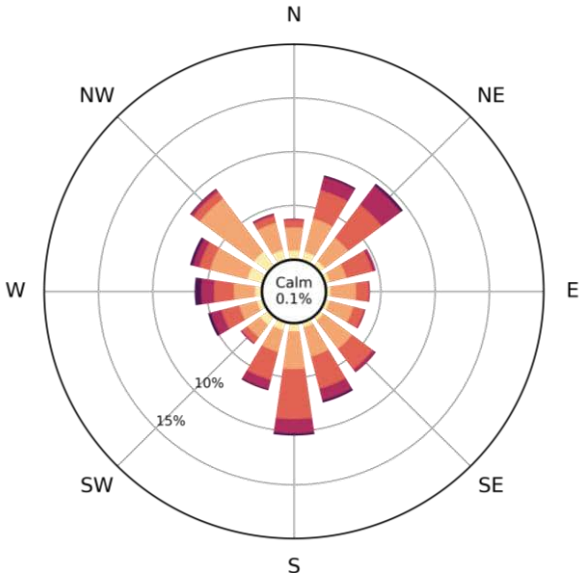


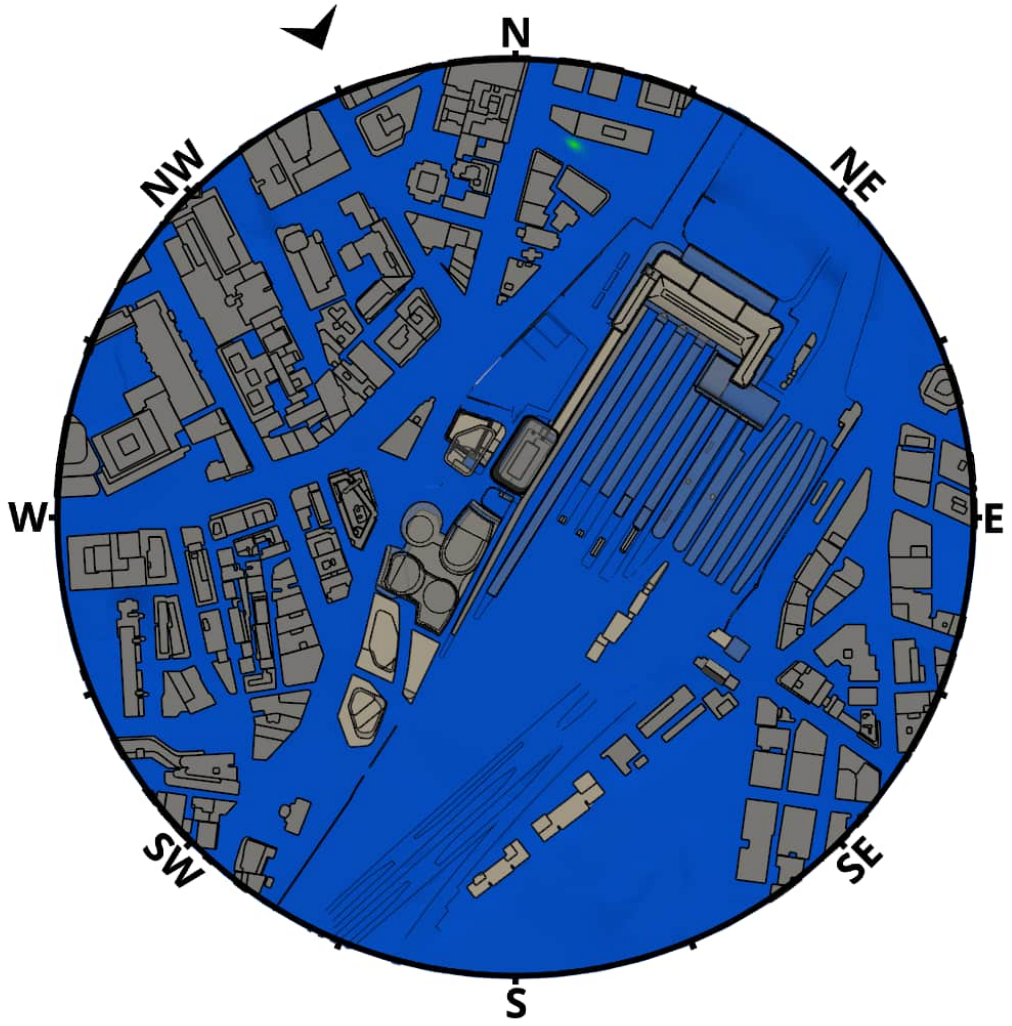


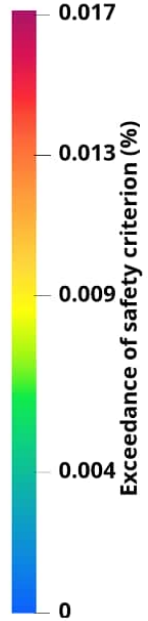


SAFETY CRITERIA - NORTH-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline



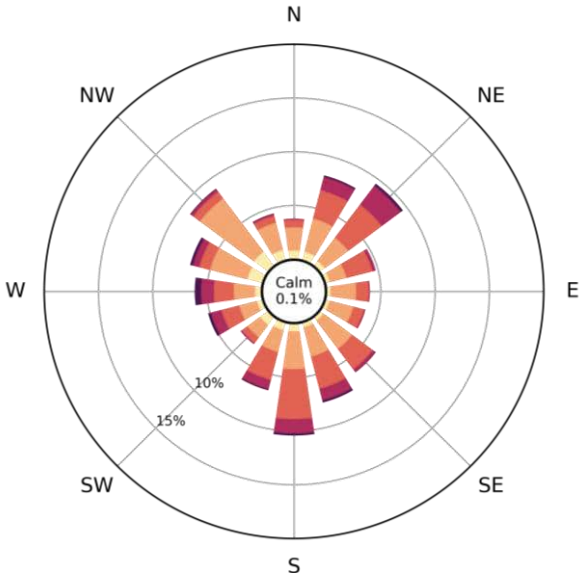


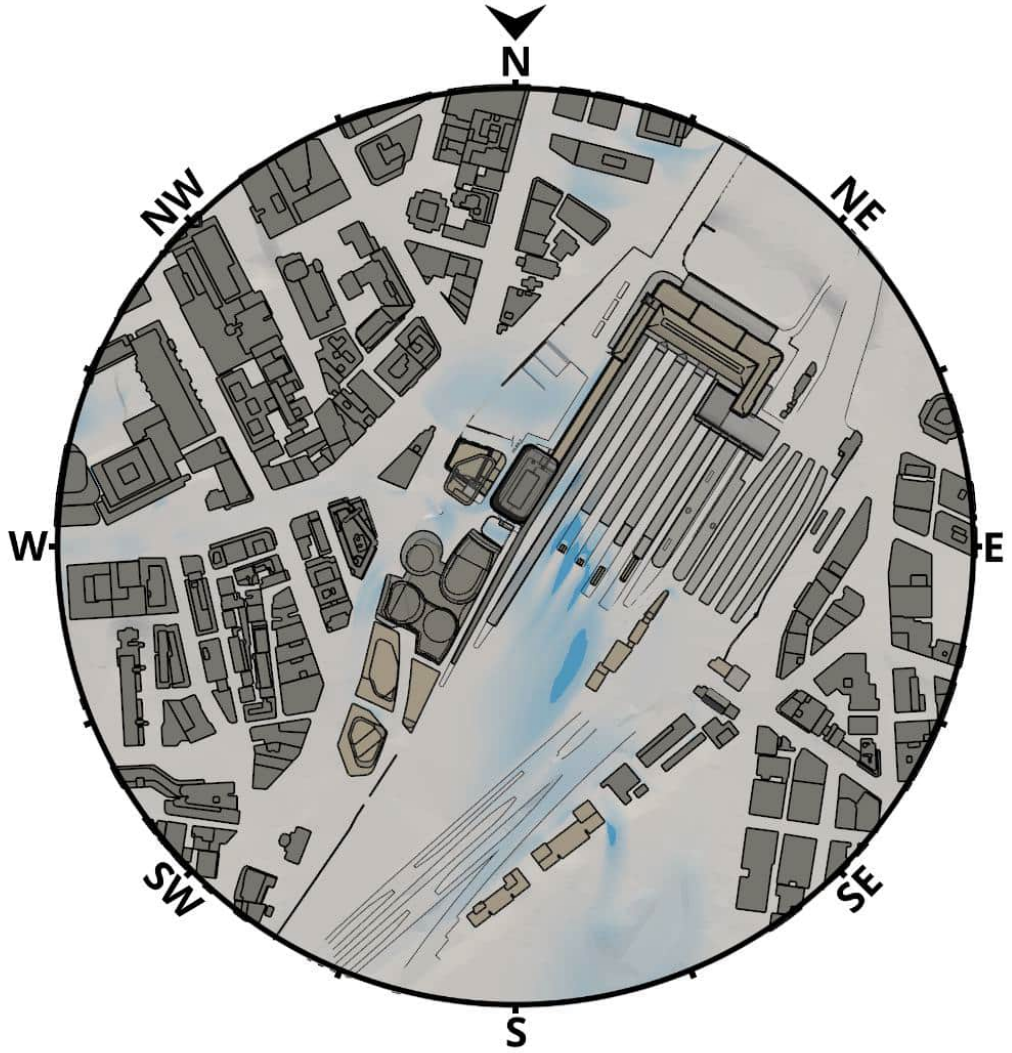


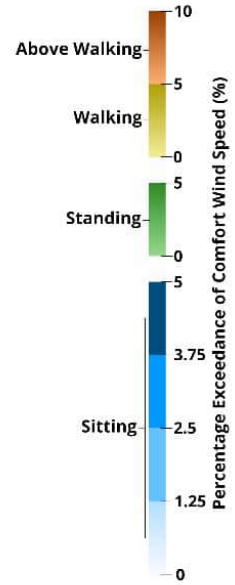
Option 2 - Directional Contributions - Comfort

COMFORT CRITERIA - NORTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

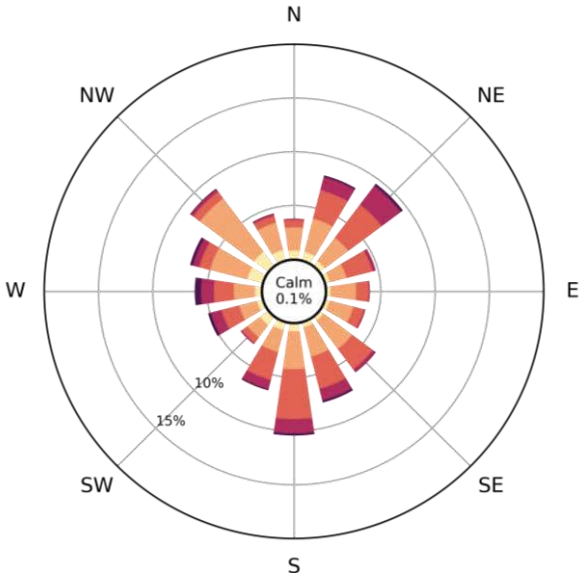


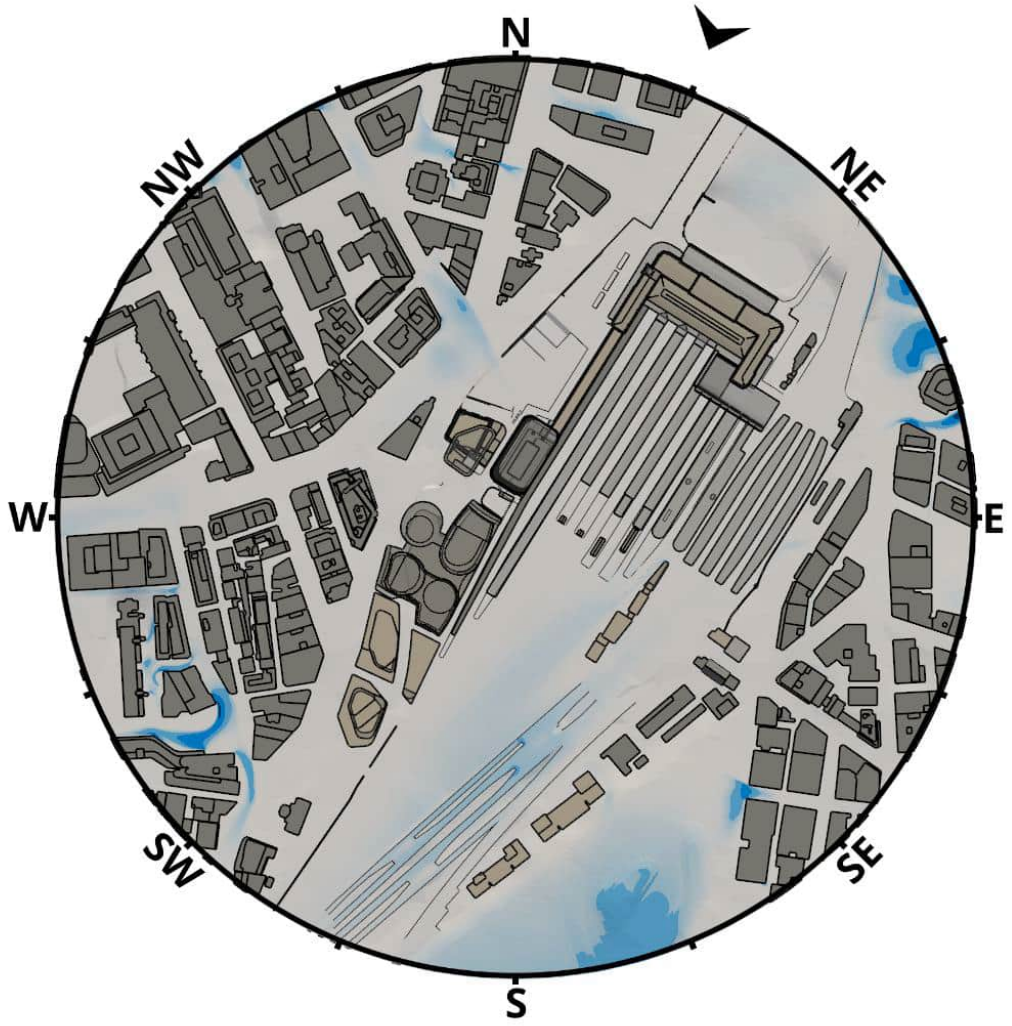


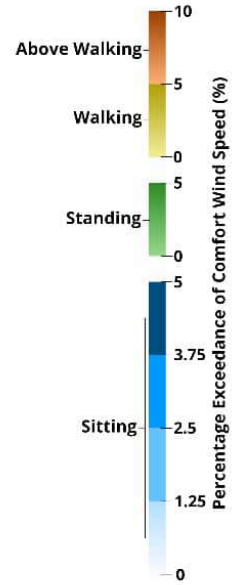


COMFORT CRITERIA - NORTH-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

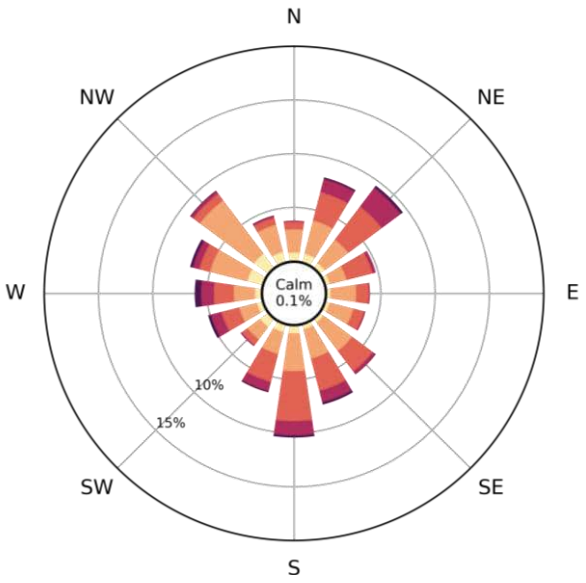


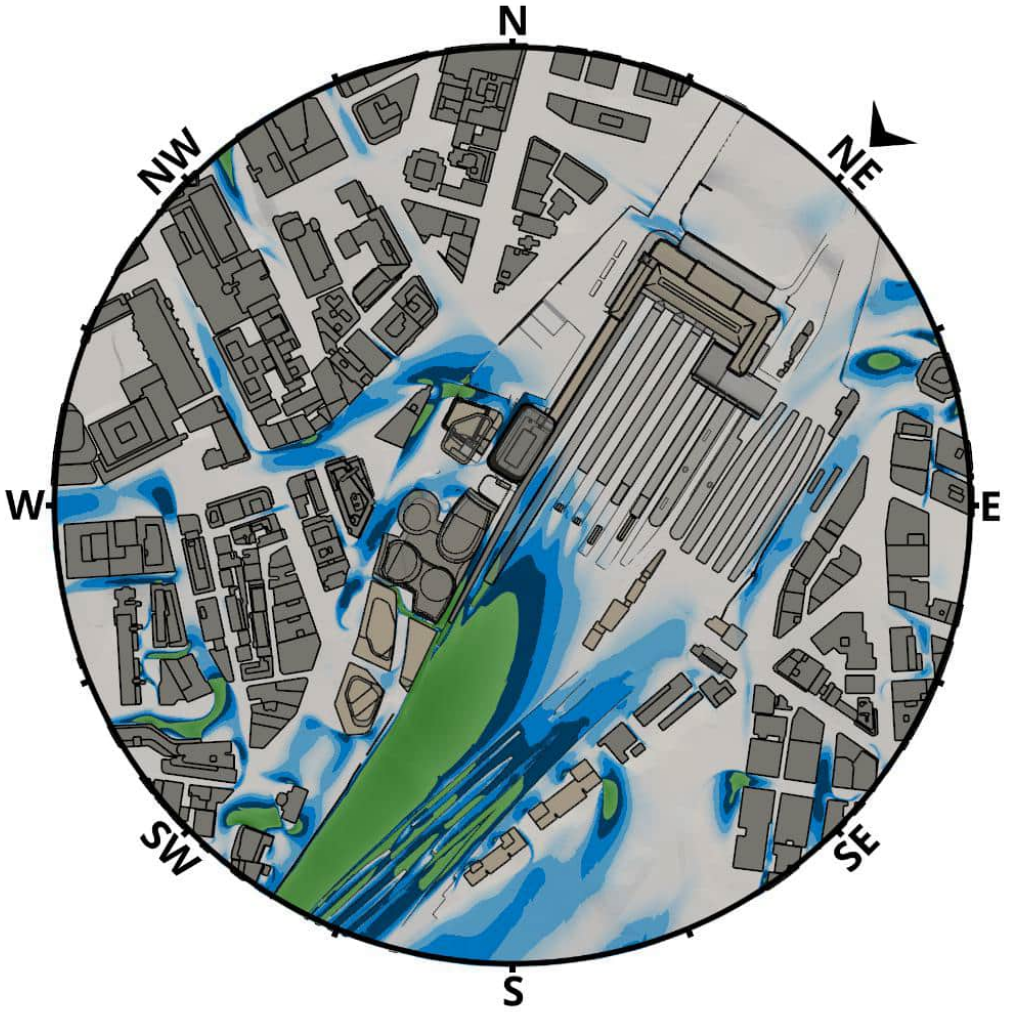


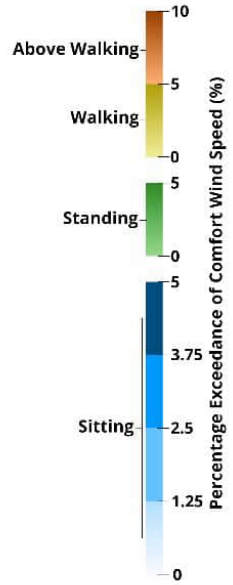


COMFORT CRITERIA - NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

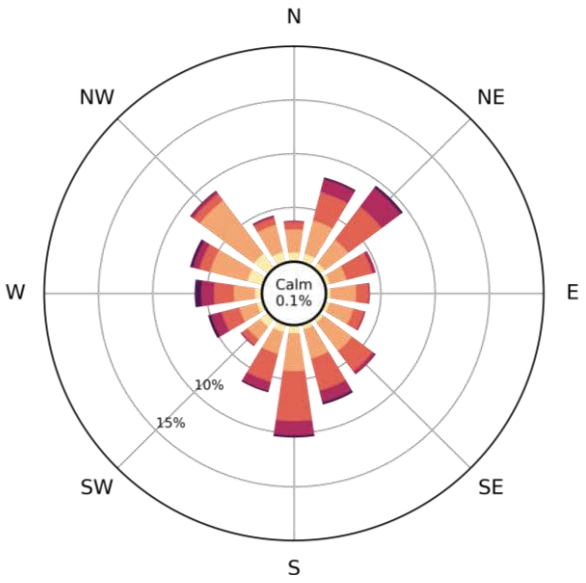


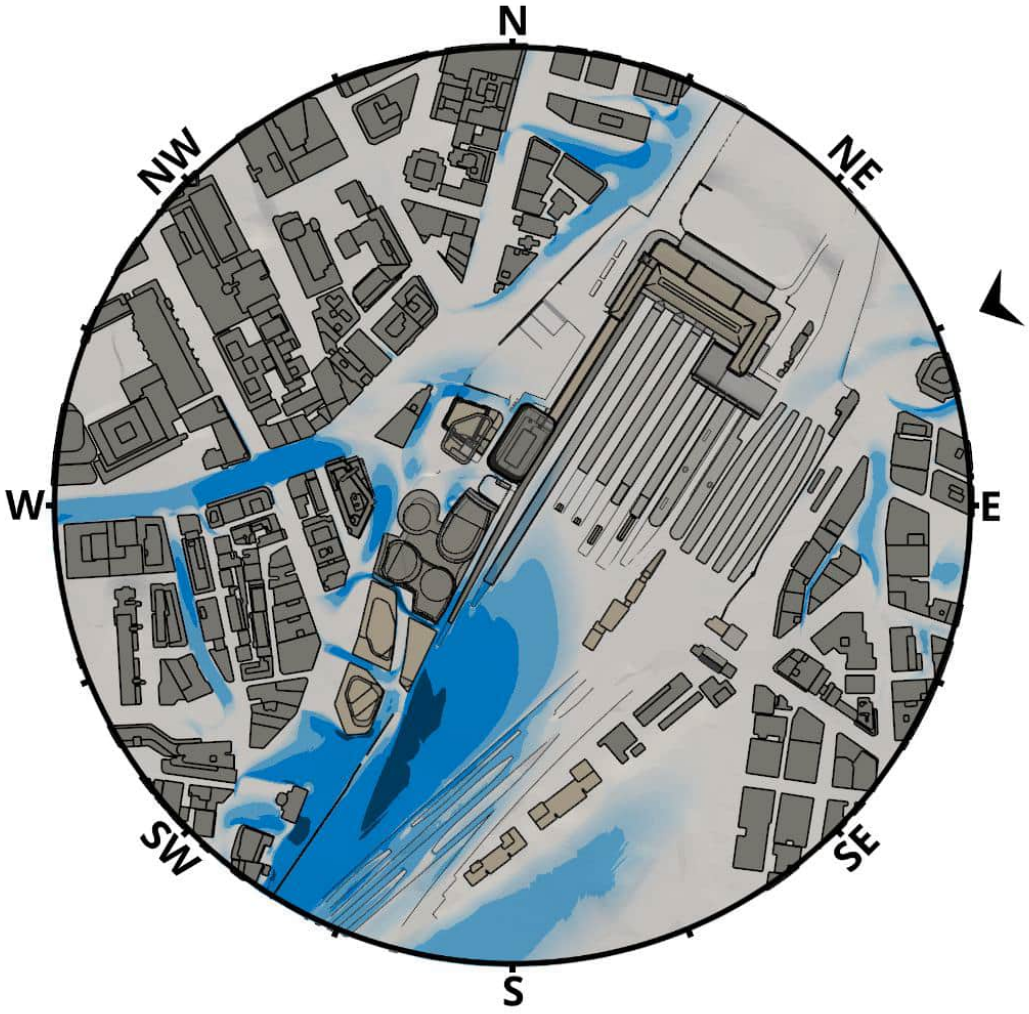


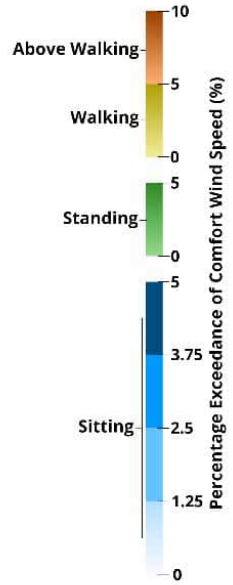


COMFORT CRITERIA - EAST-NORTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

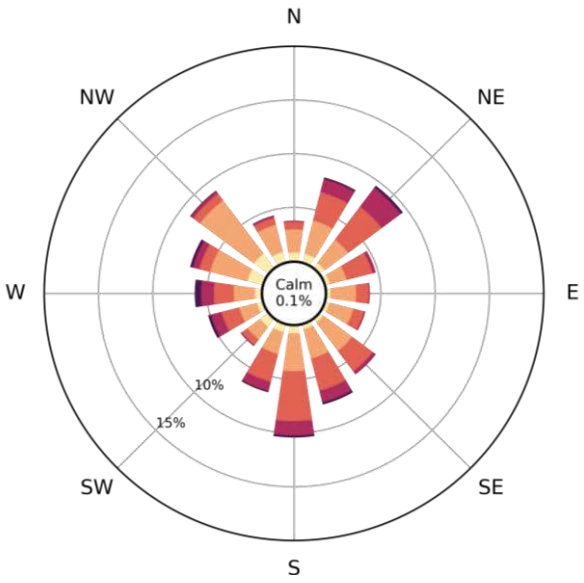


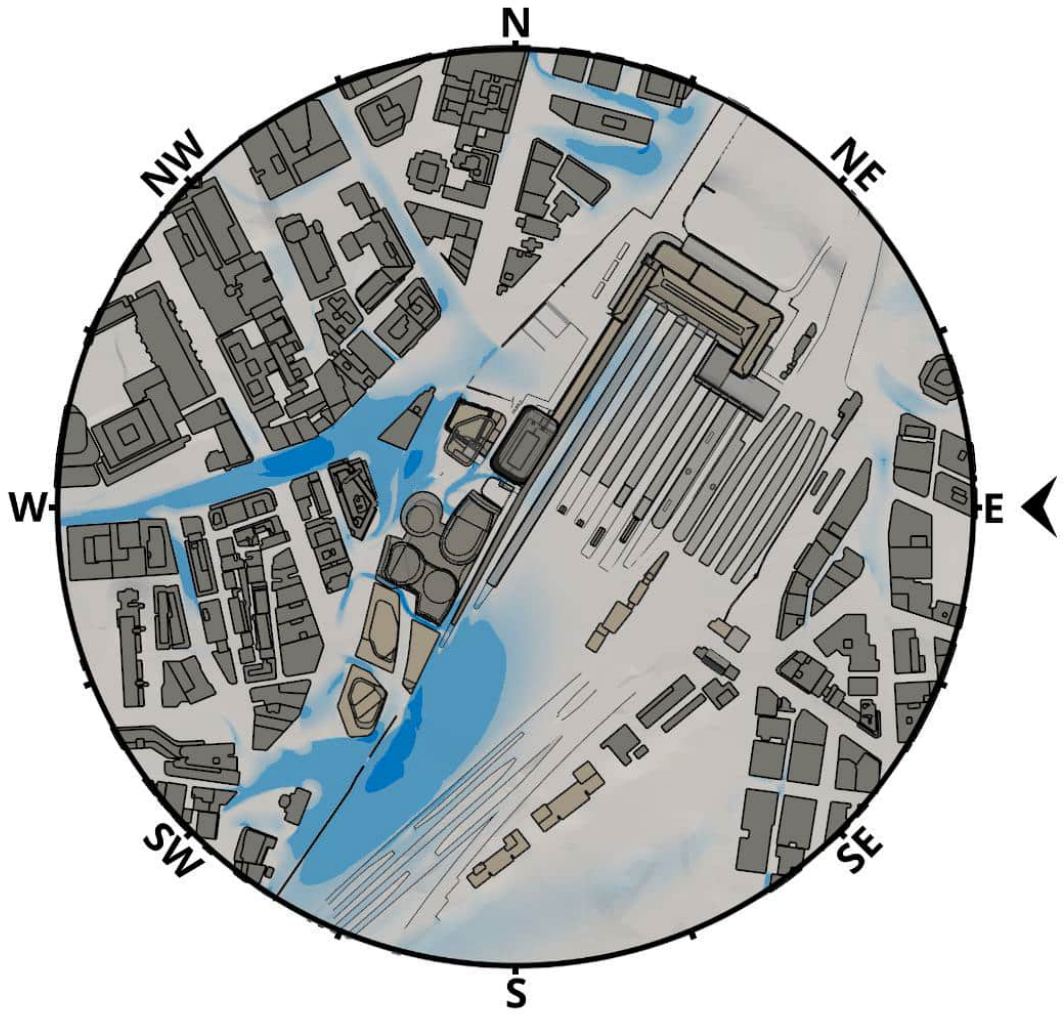


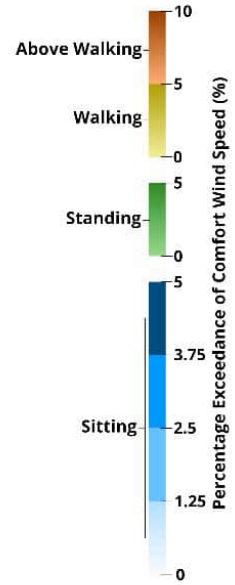


COMFORT CRITERIA - EAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

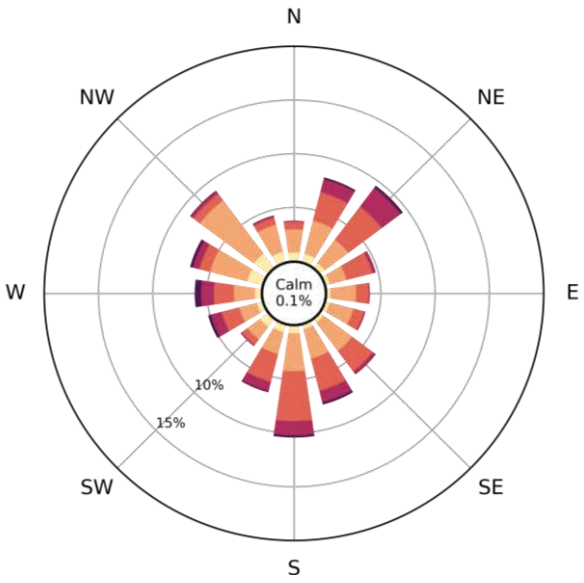


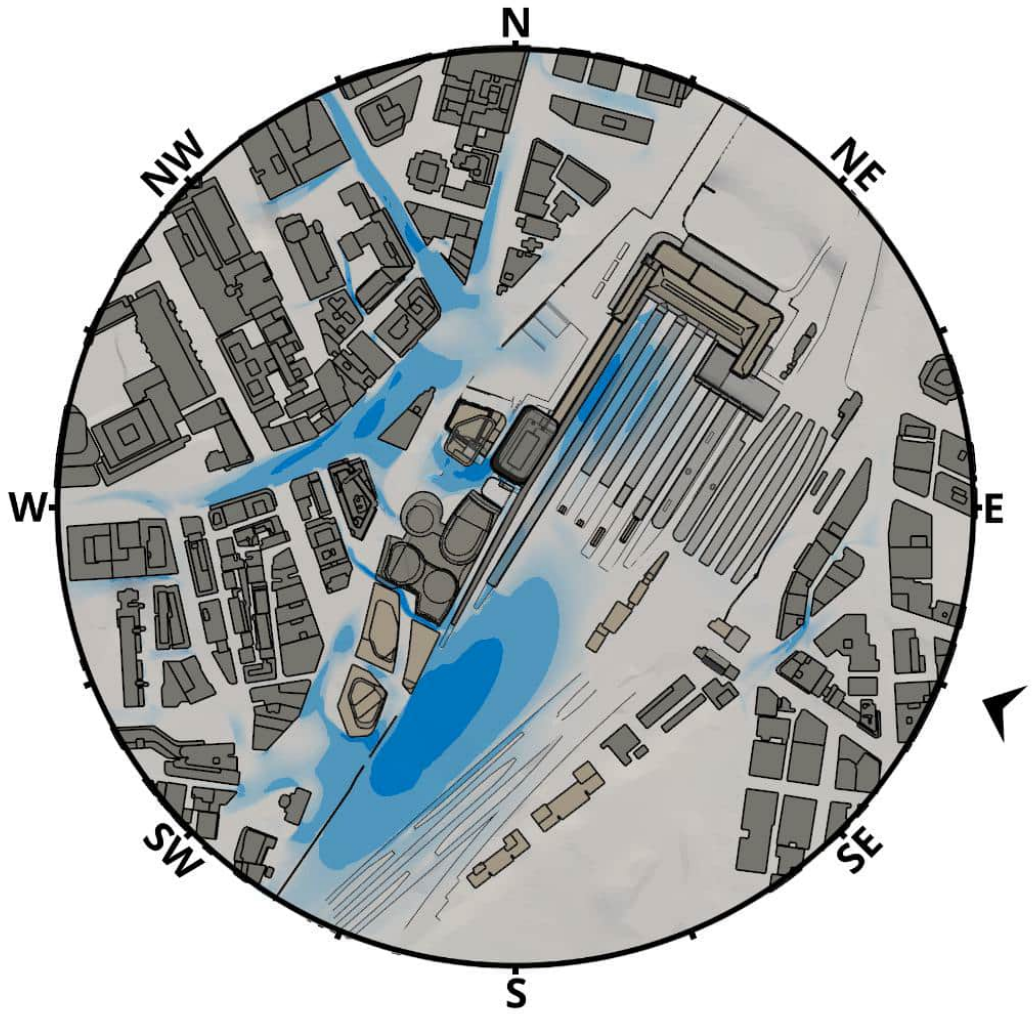


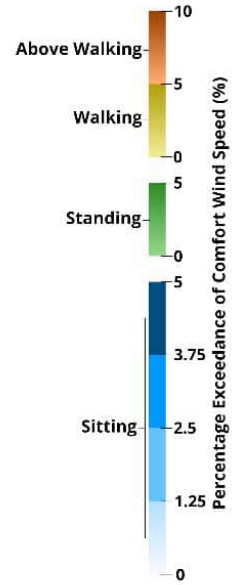


COMFORT CRITERIA - EAST-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

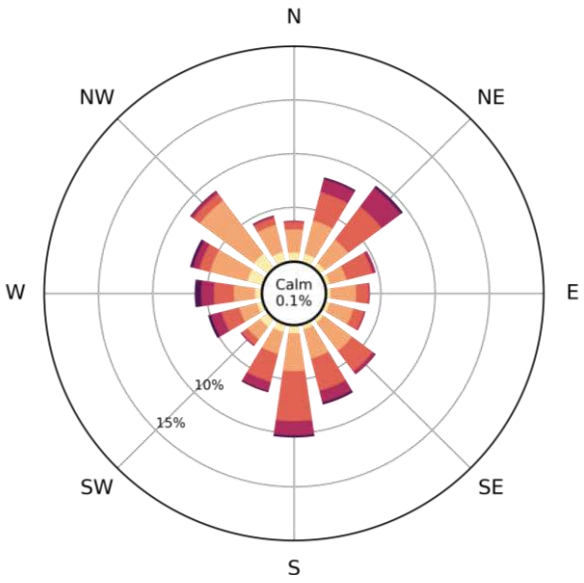


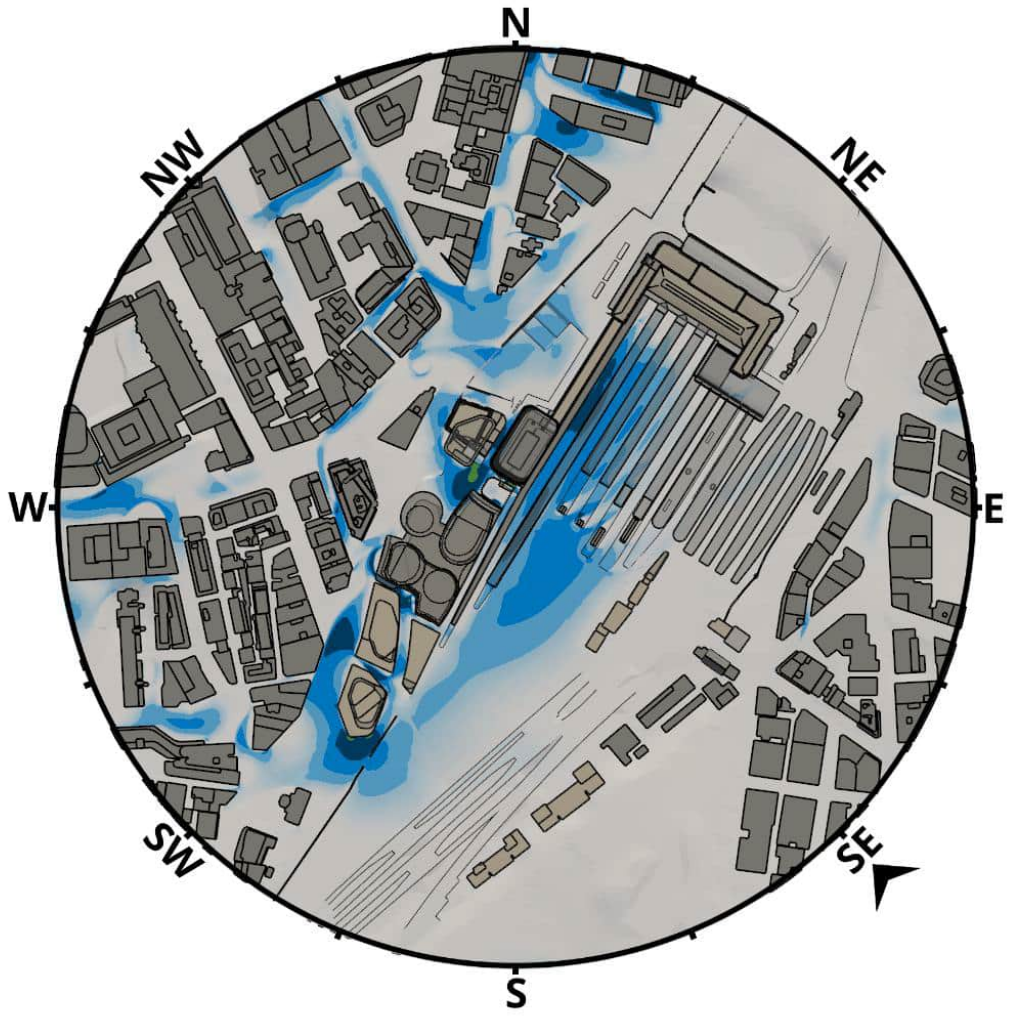


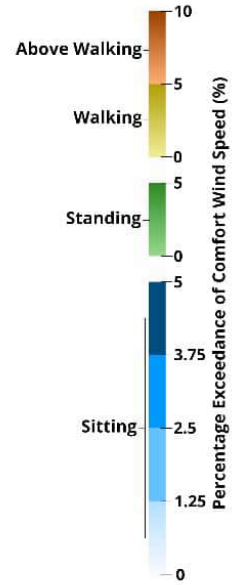


COMFORT CRITERIA - SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

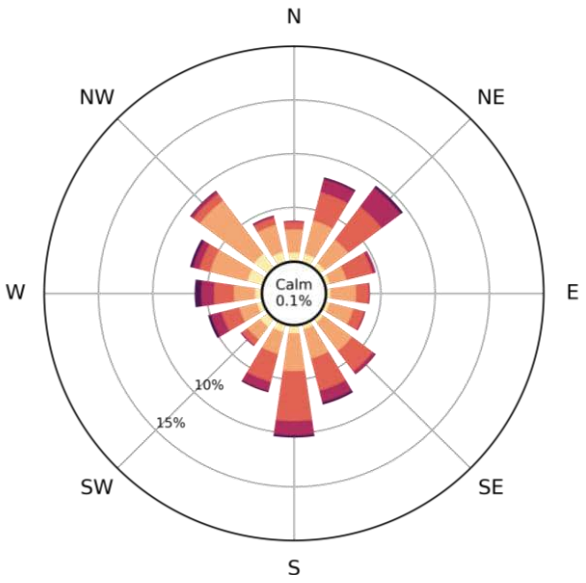


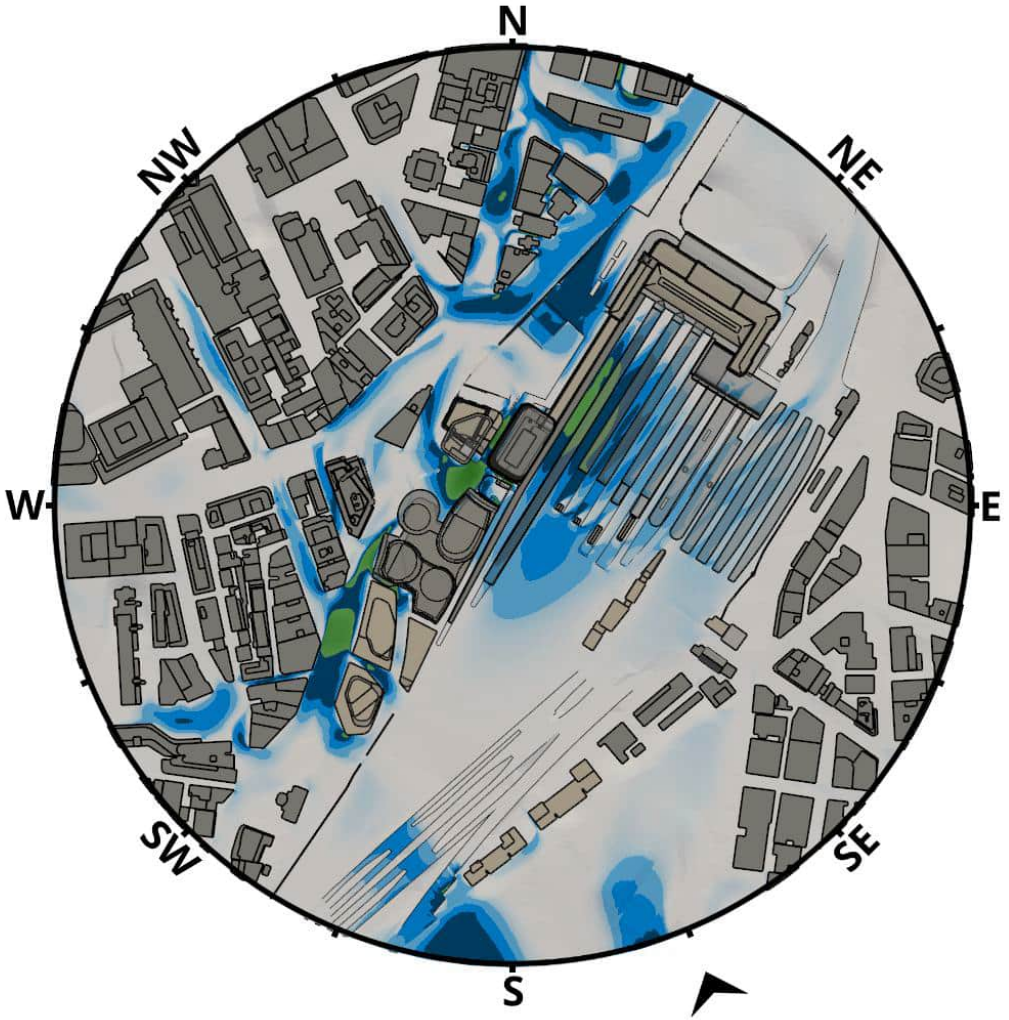


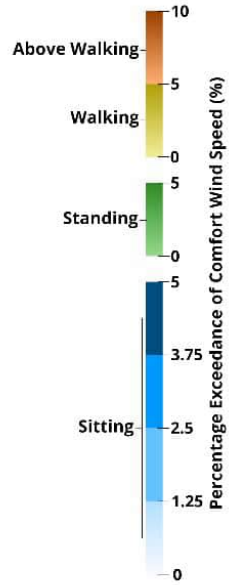


COMFORT CRITERIA - SOUTH-SOUTHEAST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

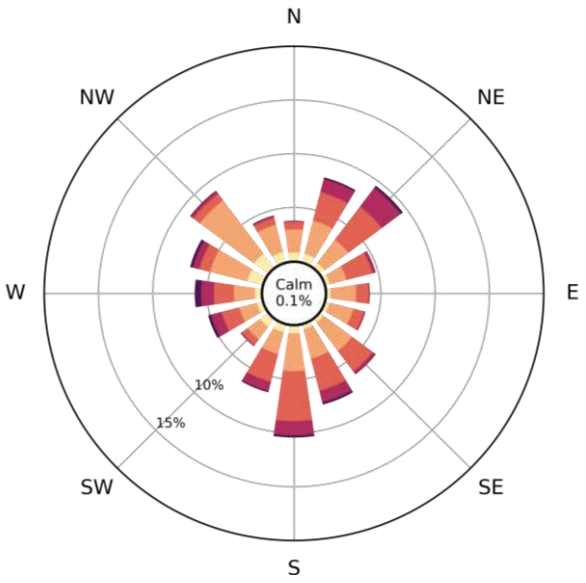


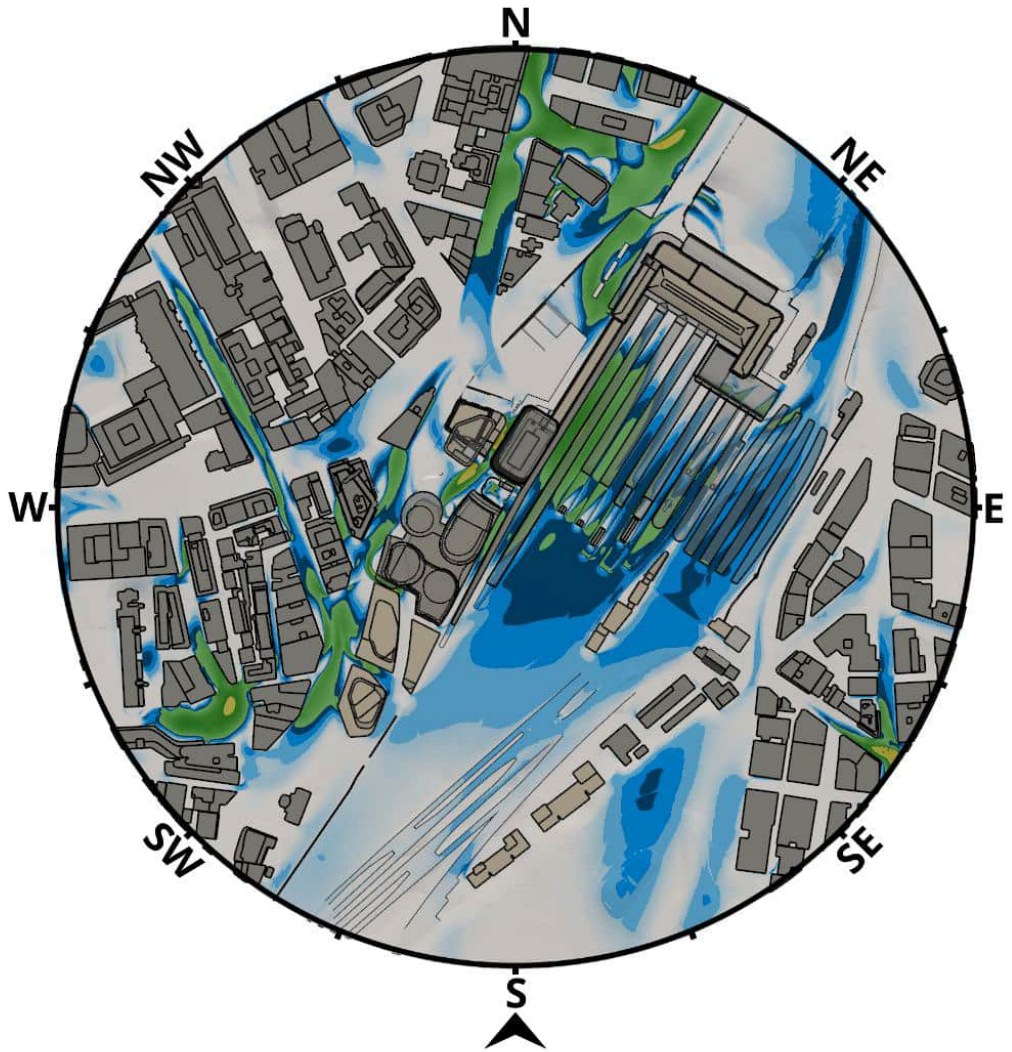


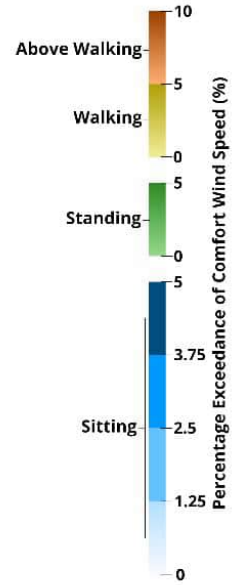


COMFORT CRITERIA - SOUTH CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

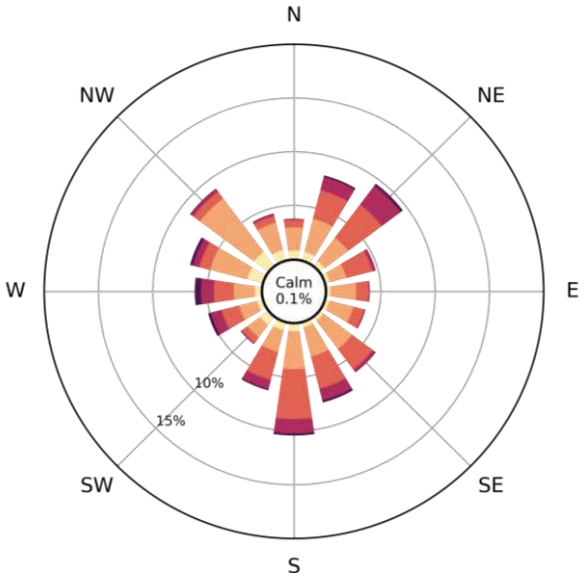


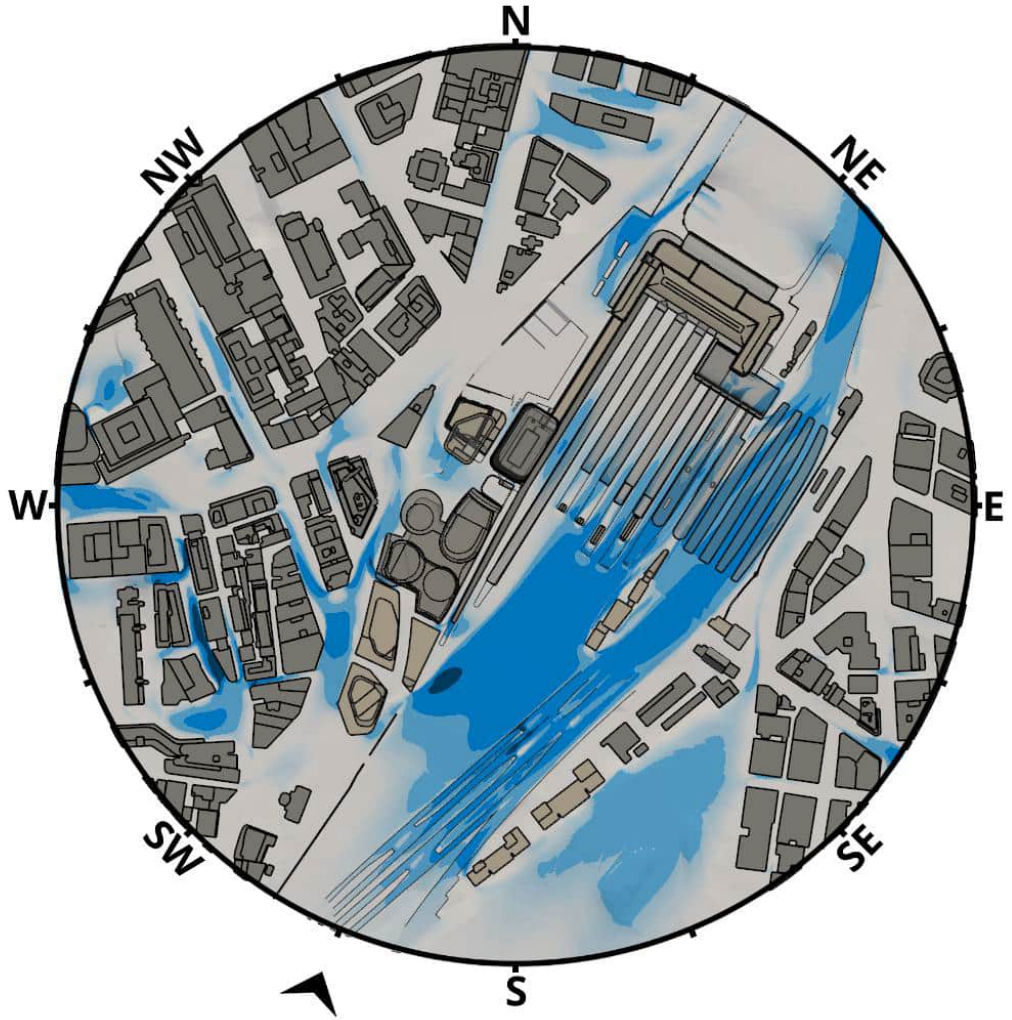


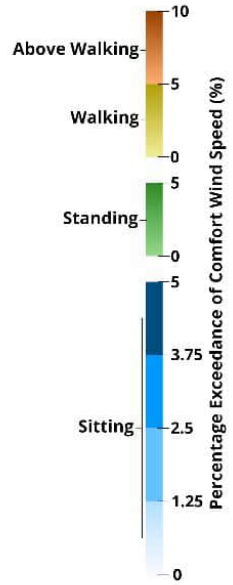


COMFORT CRITERIA - SOUTH-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

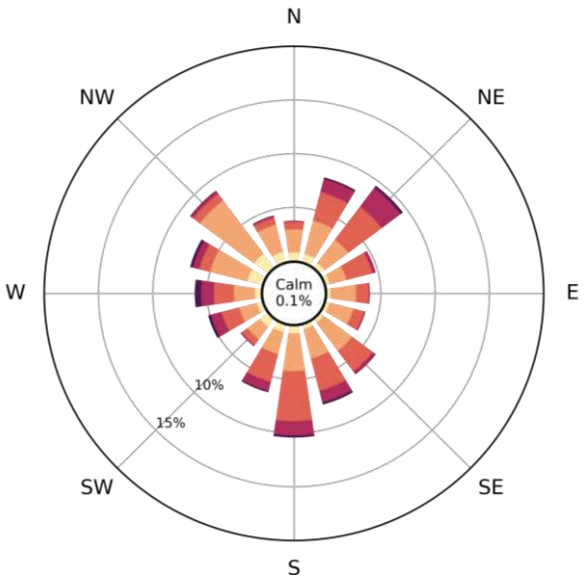


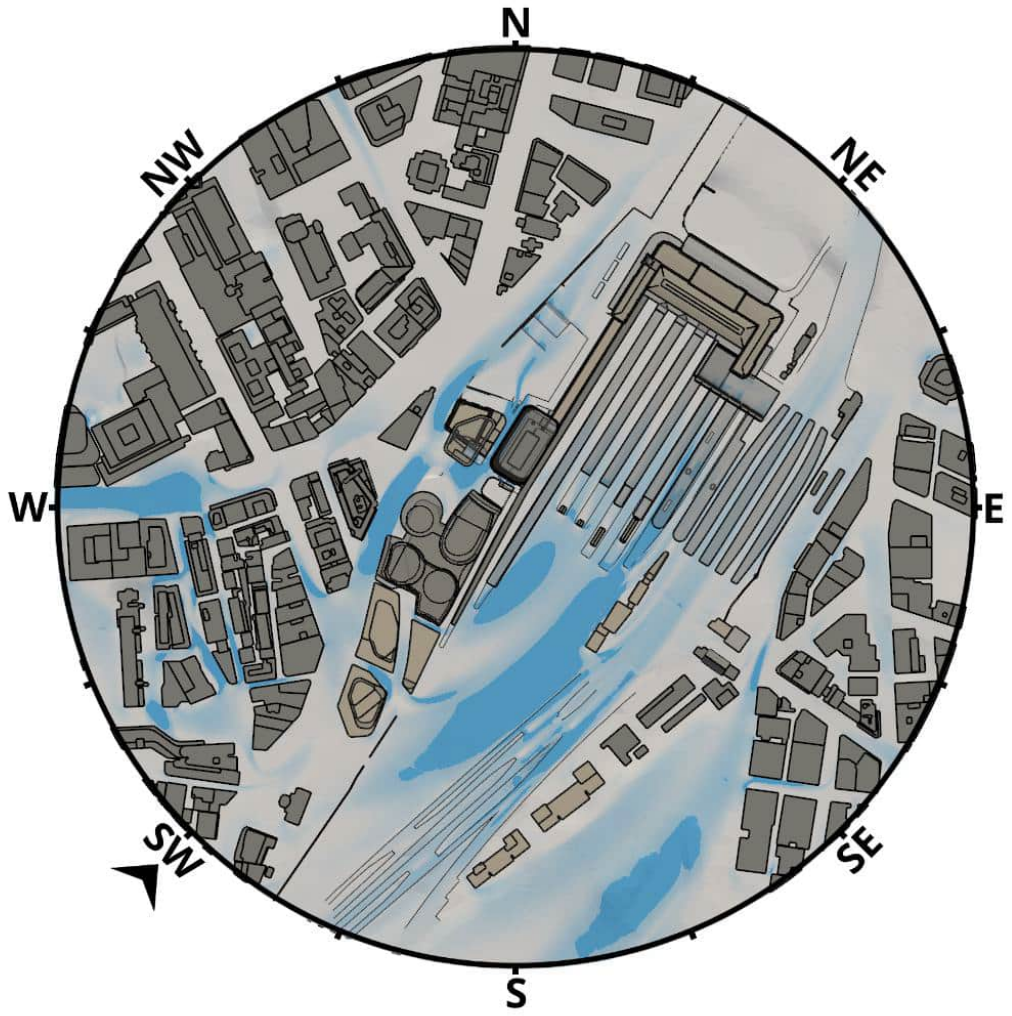


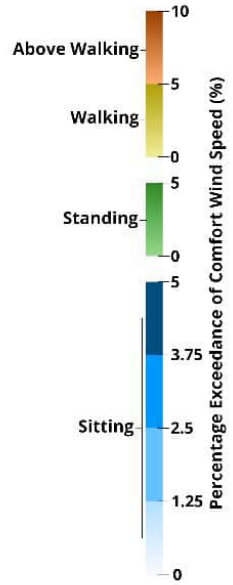


COMFORT CRITERIA - SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

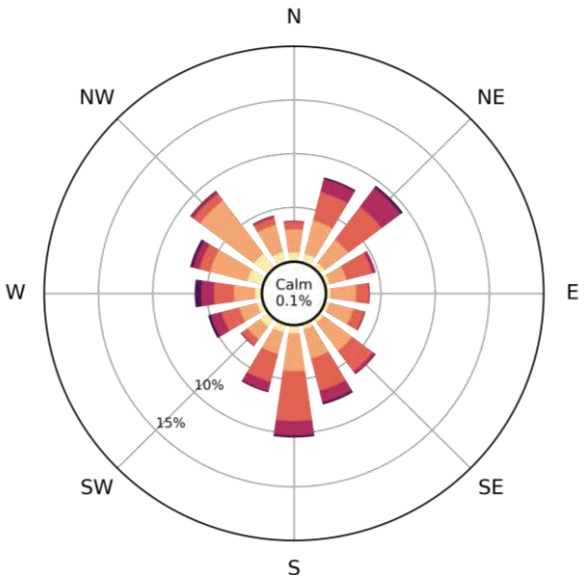


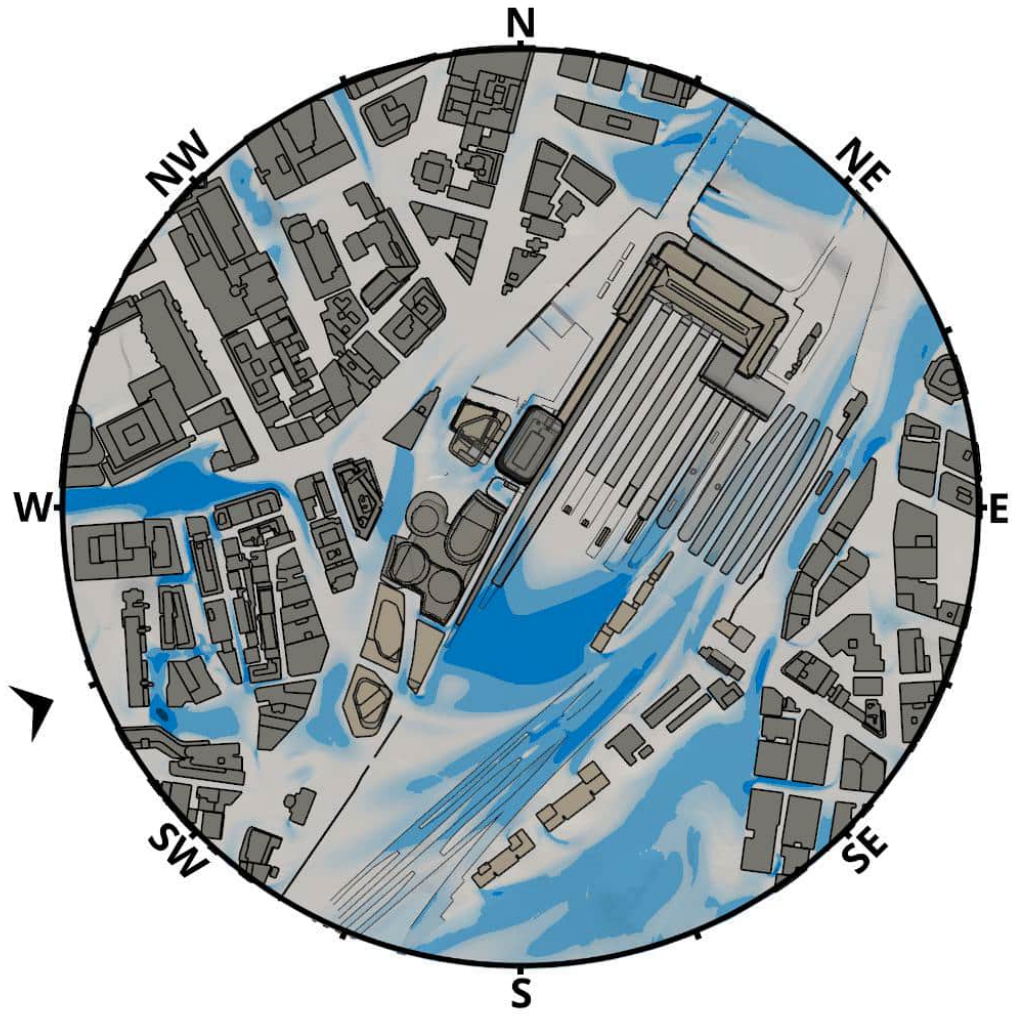


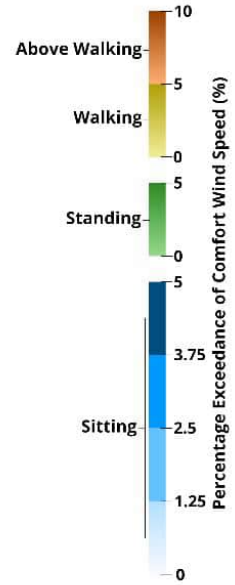


COMFORT CRITERIA - WEST-SOUTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

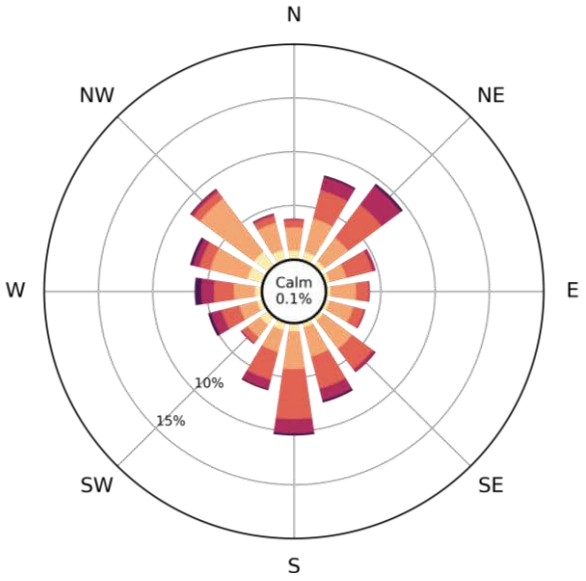


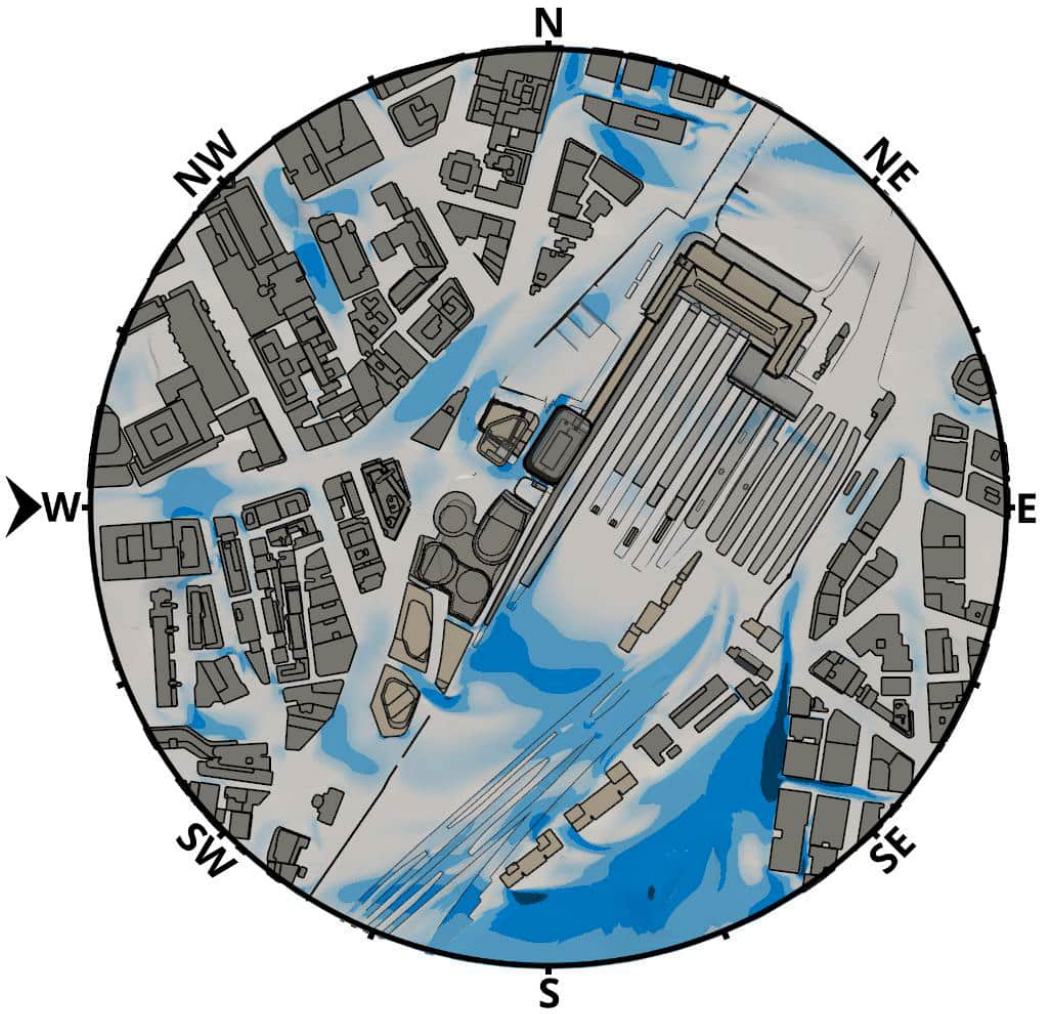


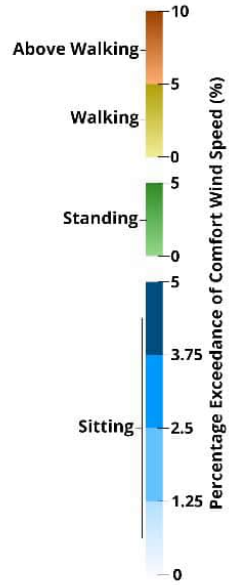


COMFORT CRITERIA - WEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

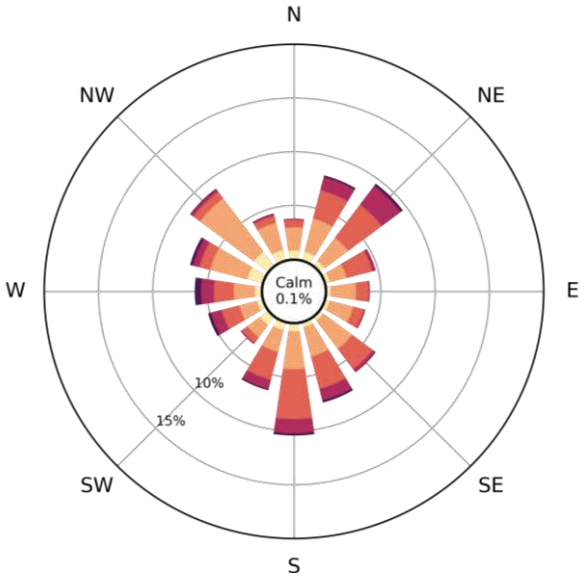


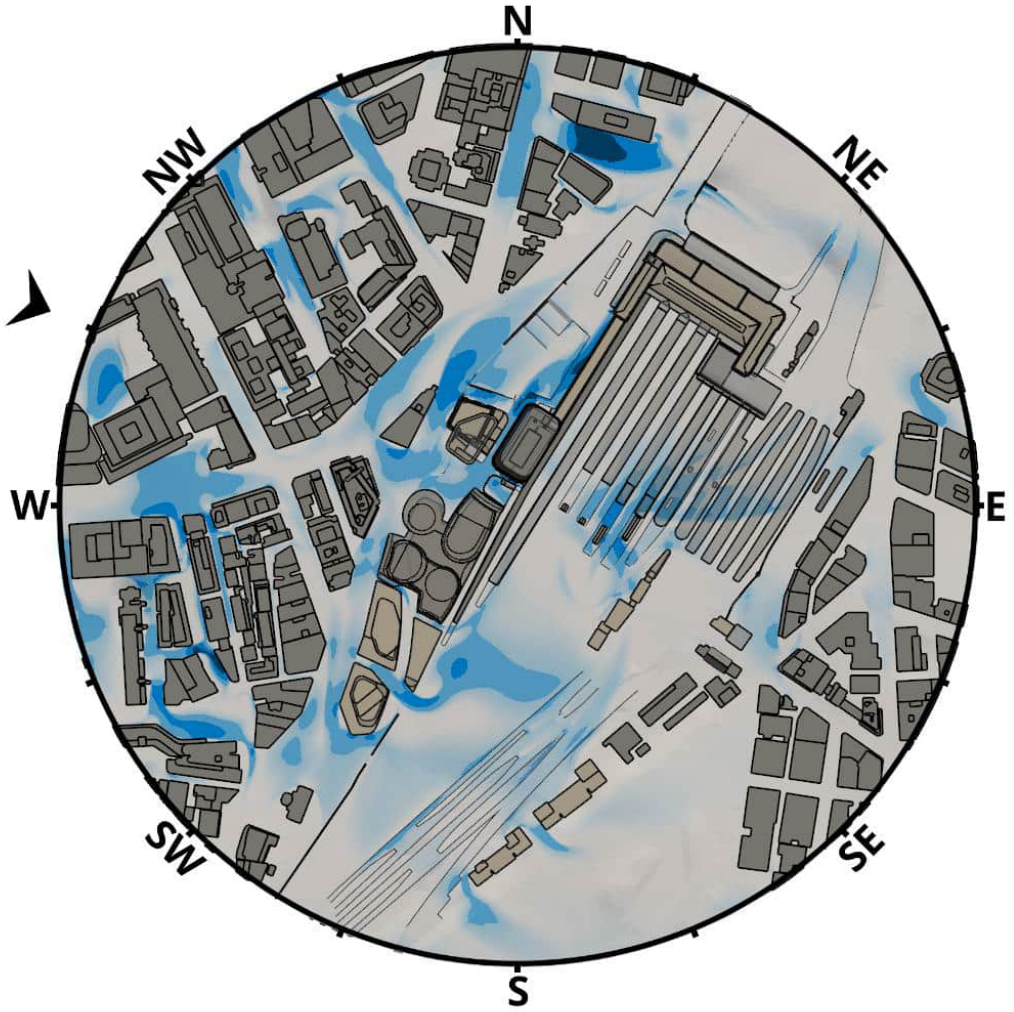


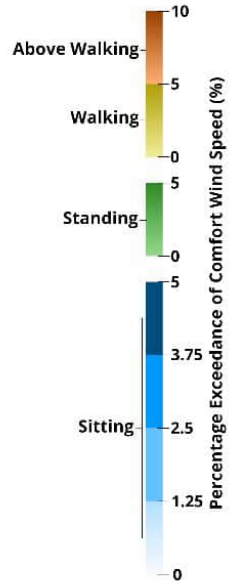


COMFORT CRITERIA - WEST-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline

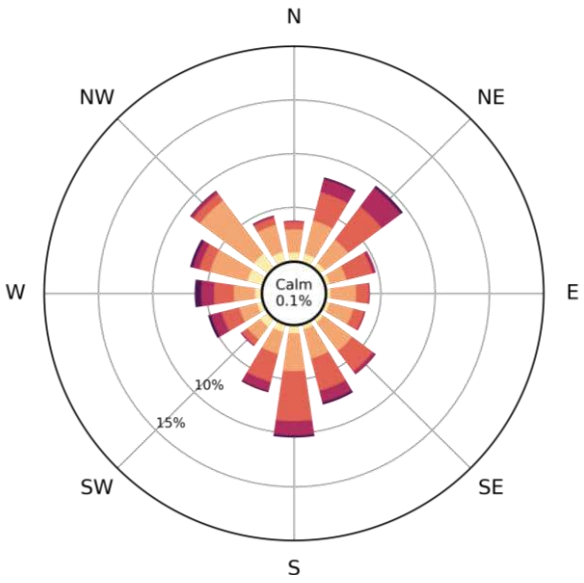


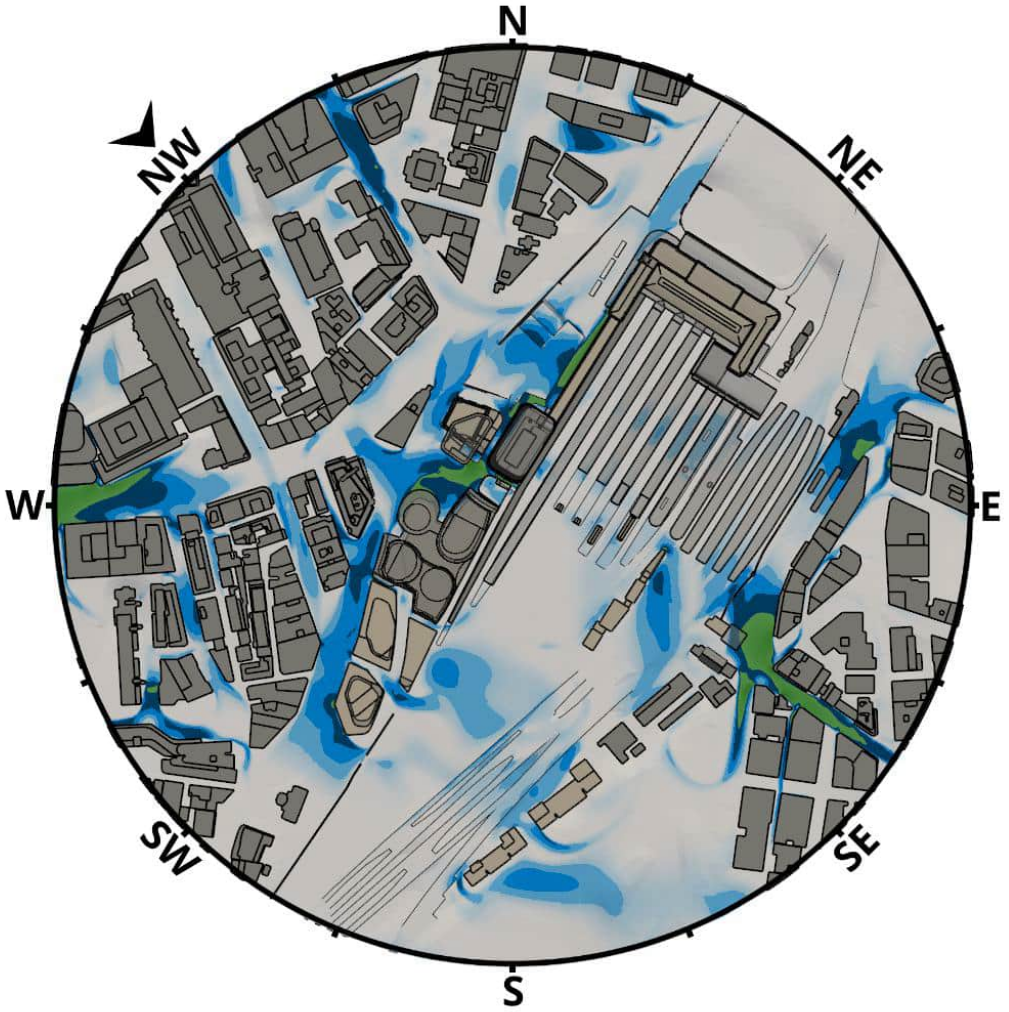


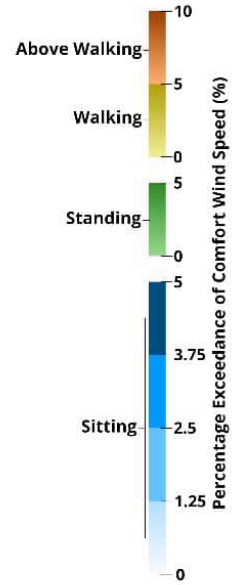


COMFORT CRITERIA - NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline







COMFORT CRITERIA - NORTH-NORTHWEST CONTRIBUTION - PLANVIEW - ANNUAL

Baseline