- **Building Relative Height Differences:**

The Laurens Street sub-precinct is comprised of the shortest buildings in the entire development. The height of the building generally increases towards the north, with the tallest buildings being H1, H2 and H3.

Group H buildings are the tallest in the sub-precinct with H1 reaching 81 m high, H2 is 68 m; sitting on the same podium of 17 m in height. The height difference between both towers is 13 m.

The building relative height difference within group M ranges very little with most buildings being approximately the same height, the maximum height difference in this group is of 9 m. Group L displays a much more diverse relative height difference range from 17 m, to 24 m and to 30 m from buildings L9 to L7. The tallest buildings in this group are L6 and L4, 48 m high.

Buildings L3 and L4 have a relative height difference of 7 m, with L4 being taller than L3. In order to avoid a dead zone arising between these two buildings, L4 should be shorter than L3.

- **Space between Buildings:**

The southern end of the Laurens Street sub precinct are closely packed together. From L3 to L9, there are no spaces in between buildings, the podiums are proposed wall to wall. Building L2 is separated from L3 and L1 with a spacing of approximately 5 m at each side. Thus, for the southern wind the deep street canyon ratio for buildings L1 and L2 is calculated to be approximately 1:1:4 (h:W:H). Referring to Figure 38, this ratio predicts that for the southern wind direction the air at ground level will remain stagnant.

The spacing between the podiums of H1 and H2, and H3 is approximately 21 m. Figure 95 shows the air flow predicted for this street. It can be appreciated that there is corner acceleration taking place off the structures in the middle of the corridor that act as windbreakers, to avoid severe wind conditions from different wind directions.

In group I, the buildings are closely spaced with only about a 2 m separation between I1 and I2. However, the height of the buildings in group I is greatly reduced compared to H. The tallest building in I is I1 at 29 m tall. The separation between buildings in group I, directly opposite H3 and H4 on Dryburgh Street is 12 m. Given the separation and their respective heights of 6 m to 8 m, from north to south, a ratio of 2:2:1 is achieved. This means that the separation and height difference are much higher than required in order to achieve acceptable air circulation at ground level.

The eastern side of the sub precinct, between Munster Terrace and Dryburgh Street, are characterised by reduced spacing between buildings. Particularly, group M as seen in Figure 30 shows very little spacing between adjacent buildings. These buildings are mostly designed as 1 or 2-storey, with some buildings reaching a maximum of 18 m tall.

- **Public Space and Layout of Vegetation:**

There are only two open areas in this sub-precinct. The civic spines are found along Munster Terrace from Arden Street to its end. As it can be appreciated in Figure 51, trees will be placed around these areas at intervals of about 20 m and they will have a canopy height of 10 to 15 m.

The northern half of Munster Terrace suffers severe wind conditions for the north and south wind directions. For the west wind direction, Figure 104 shows that the accelerated wind flow through Fogarty Street travels through the buildings in group L and onto Munster Terrace. The presence of the green strips along this street will significantly improve conditions by disrupting the wind.

4.5 Impact on Surrounding Developments

The surrounding urban areas of the Arden Precinct project are expected the experience the following changes considering the position of the surroundings and the development site:

Surroundings North of the Proposed Development: The area north of the Arden Precinct project site is a well-developed suburban surrounding. The wind flow from the north must pass over these developments to arrive at the project site. It can be seen in Figure 55, the accelerated flow generated by the buildings in these areas create a higher wind speed in the project site. Due to the north wind, the change created by the proposed development site is expected to be limited in affecting the area within the proposed development project boundary.

The wind from the south must pass over the proposed Arden Precinct project to get to the surrounding buildings to the north. Figure 66 shows that the south wind is reflected off the building in the northern suburb, increasing the wind speed at the north side of the proposed development. Thus, the surrounding buildings north for the proposed project site are not expected to experience a change in wind environment due to the proposed development.

Surroundings East of the Proposed Development: There are low rise developments east of the proposed Arden Precinct project site. The east wind passes over the surrounding developments to arrive to the project site. Due to the size of these surrounding buildings, the wind for the east direction is not expected to have any effect on Arden Precinct project site. The developments in the Arden Precinct project site towards the east side are not expected to affect the wind environment of the surrounding taking into consideration the frequency of the east wind.

The wind from the west must pass through, and over, Arden Precinct to flow over the surroundings to the east. The proposed development is expected to have an effect on the surrounding in the east by reducing the wind speed due to shielding. This effect will be a positive impact since the west wind is strong.

Surroundings South of the Proposed Development: The surroundings south of the project site are train tracks on the southwest, south; and suburban to the southeast. The wind from the south approaches the project site over these developments. The surroundings to the south will have no significant effect on the project site. The surroundings to the south are shown in Figure 108.

The wind from the north will pass over the project site to flow over the southern surroundings. This arrangement is expected to reduce the wind speed of the surrounding in the south. This reduction in wind speed from the north can be a desirable effect for the surroundings considering the strength and frequency of the north wind.

Figure 108: Map of surroundings immediately south of the Arden Precinct project site

Surroundings West of the Proposed Development: The surroundings west of the project site are train tracks, a highway and low-rise developments as shown in Figure 109. The wind from the west pass over the terrain to arrive at the project site. The proposed developments at the boundary of the project site are a considerable distance from the surrounding site in the west. Thus, the wind due to the west is not expected to affect the surrounding buildings in the west.

The wind from the east will pass over, and through, the proposed developments to arrive at the surrounding developments to the west. The proposed development will reduce the wind speed approaching from the east. However, considering the frequency of the east wind, the effect is minimal.

Figure 109: Map of surroundings west of the project site

5. RECOMMENDATIONS

5.1 Wind Criteria and Control

5.1.1 Assessment & Recommended Criteria

The assessment criteria used to analyse wind comfort and safety are based on mean wind speeds and gust equivalent mean wind speeds (comfort) and 3-second gust wind speeds (safety), as currently practiced in Melbourne Central City. The assessment criteria is in line with that defined in the 'Better Apartments' 2021 update.

The safety criterion is based on gust wind speeds of infrequent occurrence (once a year) while the comfort criteria is based on frequently occurring winds (winds that occur 80% of the time). Sets of annual maximum peak 3-second gust velocities, mean wind velocities (hourly mean wind speed) and the Gust Equivalent Mean velocities (GEM), calculated from 3-second gust divided by 1.85, were derived from meteorological data for the geographical location under consideration, for 16 wind directions. For all these possible wind directions and speeds, the regions where each of the wind speed criteria may be exceeded are then considered. Table 1 displays the safety and comfort criteria, respectively.

Most people will consider a site unacceptable for a given activity if the mean and/or gust velocities in that area during the annual maximum wind event exceeds the annual maximum wind speed criterion for that activity. The site would also be likely to be considered excessively windy for that activity during more moderate winds.

The threshold wind speed criteria are as follows:

Table 1: Wind Comfort and Safety Gust Criteria for Melbourne Central City

SAFETY CRITERIA	
Annual maximum 3 second gust speed with an annual probability of exceedance of 0.01%	**Result on perceived pedestrian comfort**
>20m/s	Unsafe (frail pedestrians knocked over)
COMFORT CRITERIA	
Maximum of: 1. Hourly mean wind speed 2. Gust equivalent mean speed (3 second gust wind speed divided by 1.85), for winds occurring 80% of the time.	**Result on perceived pedestrian comfort**
<5 m/s	Acceptable for walking (steady steps for most pedestrians)
<4 m/s	Acceptable for standing (window shopping, vehicle drop off, queuing)
<3 m/s	Acceptable for sitting (outdoor cafés, pool area, gardens)

Recommended Comfort Criteria

Table 2 lists the specific areas inside, and in close proximity to the development, and the corresponding recommended criteria.

Table 2: Recommended application of criteria

Area	Recommended Criteria
Public Footpaths	Recommended to meet the criterion for walking
Building Entrances	Recommended to meet the criterion for standing
Balconies, Podium roof, Roof Terraces	Recommended to meet the criterion for walking (refer to the discussion below)

5.2 Wind Control Mechanisms

In order to design for acceptable wind conditions within the precinct, there are numerous wind control mechanisms that can be utilised across the entire development, with varying thresholds defined for each sub-precinct. Each wind control mechanism proposed has been considered and it has been determined whether they are required or recommended to be incorporated to the design.

Due to the position and exposure of Arden North, the thresholds are more stringent in this area than they are for the rest of Arden Precinct. This is because improving wind conditions in Arden North will affect Arden Central and Laurens Street, as they are downstream of the predominant wind direction.

Arden Central is defined with lower thresholds than Laurens Street, as the average height is much taller than that of Laurens Street. Taller buildings have the potential to create more adverse conditions due to effects such as downwash.

The following sections define the benchmark wind controls required to ensure a suitable wind environment within the precinct. Testing requirements for particular buildings that pose the most significant issues within their respective sub-precincts, due to their position, are also outlined. All the wind control mechanisms proposed are in line with those prescribed in the 'Better Apartments 2021' update. The Practice Note No. PP93 provides guidance on the requirements for apartment developments of five or more storeys. The wind thresholds outlined in the next sections, follow this planning practice delineating the thresholds between the requisites for a wind impact assessment against a wind tunnel modelling study, in line with the reasoning disclosed.

Moreover, the green areas proposed for the development will help improve the conditions all around in addition to the wind control mechanisms defined. However, vegetation alone is not treated as a wind control mechanism and must therefore be incorporated as a reinforcement on already-present – fixed – controls. The 'Better Apartments 2021' update only recognises vegetation as a wind control mechanism for supplementing fixed wind amelioration elements in sitting areas (defined by the comfort criterion) on site, excluding the public domain.

The wind amelioration measures described in the following section come into play at different stages of the project. It is of paramount importance that these measures are taken into consideration and incorporated into the building as early as possible in the design development and later investigated through testing. The order of preference has been defined below in chronological order.

1. Architectural features: to be incorporated early in the design stage.
    a. Façade articulation
    b. Podium setbacks
    c. Canopies
    d. Building Separation
    e. Balustrades or parapets (for private and communal areas in buildings)

Incorporating these elements early in the project design-life will ensure the overarching success of the project. Whereas, if introduced towards the end of the design phase; or later, may incur major design alterations to incorporate these measures and their effectiveness will be ultimately limited by the design of the building. The design alterations will also significantly increase the cost of the project.

Moreover, if the building is designed with these measures in mind, the development will rely considerably less in landscaping features and other methods of amelioration. Testing will also boast of increased reliability.

2. Landscaping features: used to reinforce the fixed architectural features. (Plantation features are not included for the public domain)
    a. Fixed solid features i.e. screens, banners, columns, etc.
    b. Vegetation i.e. trees
    c. Planters
    d. Other i.e. bushes, hedges, etc.
3. Analysis: to determine the suitability of the building design within its proposed urban environment.
    a. CWE: mostly used for preliminary studies, to obtain information in a wide area and increasing the level of fidelity of wind tunnel results.
    b. Wind Tunnel Testing
    c. Wind Impacts Assessment

All wind control mechanisms proposed have been considered and have been determined whether they are required or recommended to be incorporated to the design. The following controls have been determined in accordance with the results of this study:

Sub-precinct	Wind Control Requirements	Individual Cases
Arden North	Wind tunnel testing is required for any development ≥ 20 m in height.	• Detailed CWE analysis of Fogarty Street, Henderson Street and Boundary Road.
	Developments above 20 m required to be designed with articulated facades. Buildings less than 20 m in height, with smooth façade will require wind tunnel testing.	
	Developments are required to be designed with podiums with a minimum 6 m setback.	• Building C2 will require wind tunnel testing.
	The design must include vegetation at street level. Evergreen trees are recommended. Young trees may need protection until fully grown in windy areas.	
	Building entrances are recommended not to face the North or West.	
	It is recommended to conduct a Wind Impacts Assessment on remaining buildings not prescribed by the above, nor the AS/NZS 1170.2 and Better Apartments standards.	
Arden Central	Wind tunnel testing is required for any development ≥ 30 m in height.	• Group D buildings will require wind tunnel testing.
		• Central Open Areas will require detailed CWE assessment and wind tunnel testing.
	Developments above 30 m tall are required to be designed with articulated facades Buildings less than 30 m in height with smooth façade, will require wind tunnel testing.	• Arden Station, building G4, will require detailed CWE analysis.
	Developments are required to be designed with podiums with a minimum 6 m setback. (All developments in this sub-precinct are assumed to be designed with podiums).	• Building G5 will require detailed CWE analysis and wind tunnel testing.
		• Detailed CWE analysis of corridor between G1 and G2, and through G5.
	The design must include vegetation at street level. Evergreen trees are	• Building E1 will require wind tunnel testing.

	recommended. Young trees may need protection until fully grown in windy areas.	
	Building entrances are recommended not to face the North or West.	
	It is recommended to conduct a Wind Impacts Assessment on remaining buildings not prescribed by the above, nor the AS/NZS 1170.2 and Better Apartments standards.	
Laurens Street	Wind tunnel testing is required for any development ≥ 40 m in height. (As defined in the AS/NZS 1170.2)	• Building H1 will require wind tunnel testing.
	Developments above 40 m tall are required to be designed with articulated facades. Buildings with smooth façade less than 40 m in height, will require wind tunnel testing.	
	The design must include vegetation at street level. Evergreen trees are recommended. Young trees may need protection until fully grown in windy areas.	
	Building entrances are recommended not to face the North or West.	
	It is recommended to conduct a Wind Impacts Assessment on remaining buildings not prescribed by the above, nor the AS/NZS 1170.2 and Better Apartments standards.	

6. CONCLUSION

GWTS was commissioned by the **Victorian Planning Authority (VPA)** to perform a Computational Fluid Dynamics wind study of the proposed Arden Precinct redevelopment in North Melbourne, Melbourne**.**

The analysis was performed with the information provided by the client, the North Melbourne climate and a detailed CWE analysis. The report objective is to evaluate the wind environment of the proposed Arden Precinct design and assist in understanding the wind environment.

GWTS understands that this design is one of the potential outcomes for the Arden Precinct final scheme. The wind controls and guidelines proposed in this report will allow for a range of suitable outcomes, which will alter the wind environment described in this report. If a future design deviates significantly from the one studied in this report, testing of the newly proposed scheme may be necessary.

Following the initial version of this report, the Draft Structure Plan was updated, and the sub precinct boundaries changed to reflect what is seen in Sections 1.1, 3.1, 3.2, 3.6 and 3.7. The configuration displayed in the CWE Analysis – Section 4 – has not been updated. This update has no effect on the analysis whatsoever.

The summary of the study and the main points for considerations are as follows:

- **Climate:** The wind climate of Melbourne was assessed using three Bureau of Meteorology Stations: Melbourne Airport (Station 08686282), Essendon Airport (Station 08686038) and Fawkner Beacon (Station 08686376). The North wind is the dominant wind direction. This wind direction is the most frequent as well as the strongest.
- **Wind Speed thresholds:** The threshold wind speed criteria is shown below.

The safety criterion is based on gust wind speeds of infrequent occurrence (once a year) while the comfort criteria is based on frequently occurring winds (winds that occur 80% of the time). Sets of annual maximum peak 3-second gust velocities, mean wind velocities (hourly mean wind speed) and the Gust Equivalent Mean velocities (GEM), calculated from 3-second gust divided by 1.85, were derived from meteorological data for the geographical location under consideration, for 16 wind directions.

Table 1: Wind Comfort and Safety Gust Criteria for Melbourne Central City	
SAFETY CRITERIA	
Annual maximum 3 second gust speed with an annual probability of exceedance of 0.01%	**Result on perceived pedestrian comfort**
>20m/s	Unsafe (frail pedestrians knocked over)
COMFORT CRITERIA	
Maximum of: 1. Hourly mean wind speed 2. Gust equivalent mean speed (3 second gust wind speed divided by 1.85), for winds occurring 80% of the time.	**Result on perceived pedestrian comfort**
<5 m/s	Acceptable for walking (steady steps for most pedestrians)
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<3 m/s	Acceptable for sitting (outdoor cafés, pool area, gardens)

Table 2: Recommended application of criteria	
Area	**Recommended Criteria**
Public Footpaths	Recommended to meet the criterion for walking
Building Entrances	Recommended to meet the criterion for standing
Balconies, Podium roof, Roof Terraces	Recommended to meet the criterion for walking (refer to the discussion below)

- **CWE Analysis:**

The CWE analysis conducted, yielded results showing that the north wind direction has the most severe impact on the proposed development due to its dominance in the local wind climate in both frequency and strength**.** The simulation domain was discretised with around 20 million cells, with inflow boundary condition specified with the wind profile for Terrain Category 3, turbulence intensity and dissipation rate.

The north wind directions is shown to be dominant throughout the year. The south wind direction is shown to become the prominent wind direction during the summer months allowing for the passive cooling of the precinct. The analysis has shown that the sub precinct with the highest potential to improve conditions across the entire precinct is Arden North. It is also the most sensitive due to its northern location and presence of large open areas. Thus, wind control mechanisms were made more stringent for this sub precinct.

The design scheme of the precinct allows for the north, south and west winds to penetrate far into the development allowing for cooling and proper ventilation. However, corner

acceleration and channelling events are prone to occur and thus, the wind control mechanisms presented in this study must be followed.

Building separation must be considered carefully and the objective for the separation distance: whether the street is set to become an air path or not for example. The general guideline for building separation is to allow a minimum distance between buildings to be equal to the widest dimension of the tower floor plate. However, this is not usually the case in densely packed urban areas. Many parameters influence the appropriate separation distance between adjacent buildings, including the position of these, their size and orientation, shape, overshadowing, pedestrian level wind and relative height among others. A strong limitation for the separation distance in this case, is that the streets are already present. Therefore, utilising the tools and guidelines provided will help towards an appropriate design, and careful assessment of the development will yield their effectiveness.

The inclusion of air paths to the precinct design will improve ventilation and cooling of these areas, ultimately decreasing the average temperature of the precinct during the summer months. The north to south orientation will affect the cooling capacity, and the east to west orientation will affect the ventilation capacity of the precinct. Using the equation shown in Section 3.1, will yield an approximation of the effective width for the creation of an air path. The air path width changes throughout the precinct at different locations, this calculation will help guide the effective street widths for the creation of air paths. This method was derived for the Hong Kong climate which has a main objective to promote wind flow, whereas the Melbourne climate leans more towards shielding.

Sources of error can be introduced in three forms into the simulation: through the accuracy and resolution of geometrical models, numerical errors and appropriateness of the boundary conditions initially defined.

The precinct 3D model provided to GWTS by the client came in two sets, one contained all the buildings within the proposed Arden Precinct, as well as its immediate surroundings. The second set contained the model of the topography of the precinct. GWTS combined both models, ensuring that all the buildings rested on the terrain and that all developments were sealed to run the simulation correctly.

One of the assumptions made for the simulation was that all the buildings were modelled to have smooth facades. This has a significant impact on the results, as the wind speeds at pedestrian level, predicted by the simulation, will be considerably higher. Moreover, the simulation did not account for any vegetation at street level. The presence of vegetation will help improve conditions, therefore the conditions predicted by the CWE analysis are worse than may be expected at the actual site.

Lastly, the software simulates all wind directions with the same probability of occurrence. The climate study shows that the east wind direction is almost negligible in Melbourne, while the north wind direction is dominant. Thus, the results for the east wind results do not carry equal weight as the north wind results and are analysed with different degrees of scrutiny.

The wind control mechanisms outlined in this report are accepted by the ‘Better Apartments’ design guidelines and its 2021 update. All wind control mechanisms proposed have been considered and have been determined whether they are required or recommended to be incorporated to the design.

Sub-precinct	Wind Control Requirements	Individual Cases
Arden North	Wind tunnel testing is required for any development ≥ 20 m in height.	
	Developments above 20 m required to be designed with articulated facades. Buildings less than 20 m in height, with smooth façade will require wind tunnel testing.	• Detailed CWE analysis of Fogarty Street, Henderson Street and Boundary Road.
	Developments are required to be designed with podiums with a minimum 6 m setback.	
	The design must include vegetation at street level. Evergreen trees are recommended. Young trees may need protection until fully grown in windy areas.	• Building C2 will require wind tunnel testing.
	Building entrances are recommended not to face the North or West.	
	It is recommended to conduct a Wind Impacts Assessment on remaining buildings not prescribed by the above, nor the AS/NZS 1170.2 and Better Apartments standards.	
Arden Central	Wind tunnel testing is required for any development ≥ 30 m in height.	• Group D buildings will require wind tunnel testing.
		• Central Open Areas will require detailed CWE assessment and wind tunnel testing.
	Developments above 30 m tall are required to be designed with articulated facades Buildings less than 30 m in height with smooth façade, will require wind tunnel testing.	• Arden Station, building G4, will require detailed CWE analysis.
	Developments are required to be designed with podiums with a minimum 6 m setback. (All developments in this sub-precinct are assumed to be designed with podiums).	• Building G5 will require detailed CWE analysis and wind tunnel testing.
		• Detailed CWE analysis of corridor between G1 and G2, and through G5.
	The design must include vegetation at street level. Evergreen trees are recommended. Young trees may need protection until fully grown in windy areas.	• Building E1 will require wind tunnel testing.

	Building entrances are recommended not to face the North or West.	
	It is recommended to conduct a Wind Impacts Assessment on remaining buildings not prescribed by the above, nor the AS/NZS 1170.2 and Better Apartments standards.	
Laurens Street	Wind tunnel testing is required for any development ≥ 40 m in height. (As defined in the AS/NZS 1170.2)	• Building H1 will require wind tunnel testing.
	Developments above 40 m tall are required to be designed with articulated facades. Buildings with smooth façade less than 40 m in height, will require wind tunnel testing.	
	The design must include vegetation at street level. Evergreen trees are recommended. Young trees may need protection until fully grown in windy areas.	
	Building entrances are recommended not to face the North or West.	
	It is recommended to conduct a Wind Impacts Assessment on remaining buildings not prescribed by the above, nor the AS/NZS 1170.2 and Better Apartments standards.	

7. References

1) Australian Standard 1170.2:1989, Wind actions
2) Melbourne, W. H., “Criteria for Environmental Wind Conditions”, Jour. Industrial Aerodynamics, Vol. 3, 241-249,1978
3) Australian Wind Engineering Society, “Cladding Pressure and Environmental Wind Studies” Quality Assurance Manual, 2001
4) AS/NZS 1170.2 Supplement 1: 2011
5) Guidelines for Pedestrian Wind Effects Criteria, Australasian Wind Engineering Society, September 2014
6) Designing High-Density Cities For Social and Environmental Sustainability, Chapter 10: Designing for Urban Ventilation, Edward Ng, 2010

8. Drawings

3051_SP21_LAND USE SUB-PRECINCTS	7/06/2021 9:15 AM	Adobe Acrobat D...	143 KB
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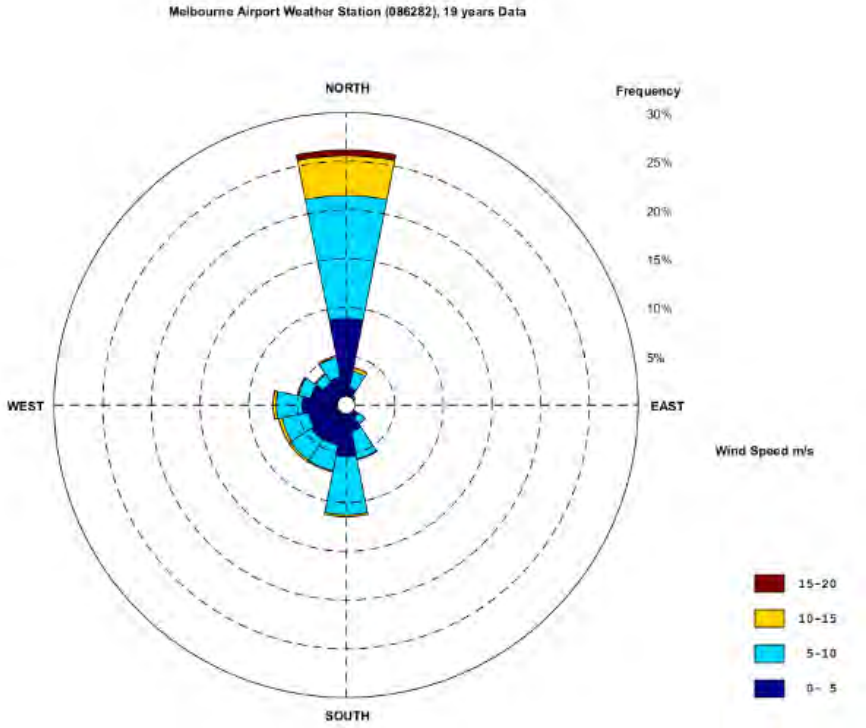
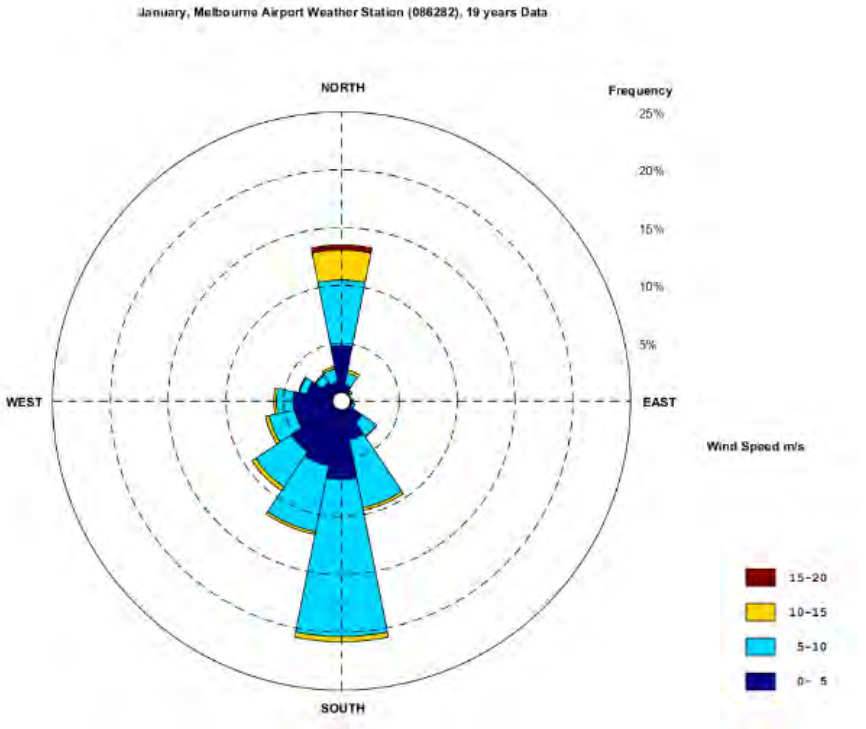
APPENDIX A

Polar Plots of wind frequency from three Bureau of Meteorology Stations
Melbourne Airport
Essendon Airport
Fawkner Beacon

MELBOURNE AIRPORT


Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
30%
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


January, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
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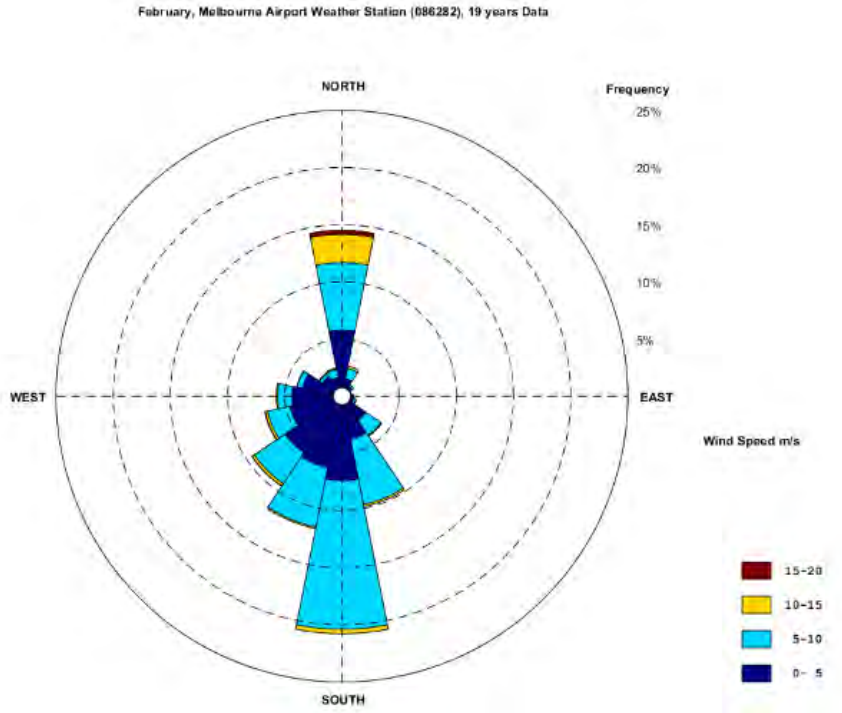
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5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NORTH
Frequency
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SOUTH
Wind Speed m/s
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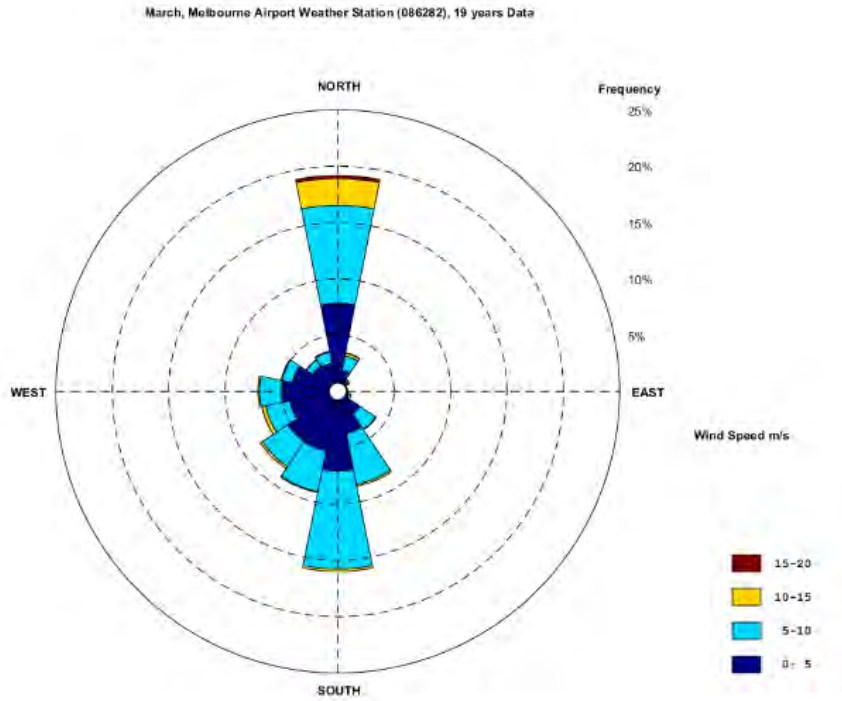
5-10
0- 5


March, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
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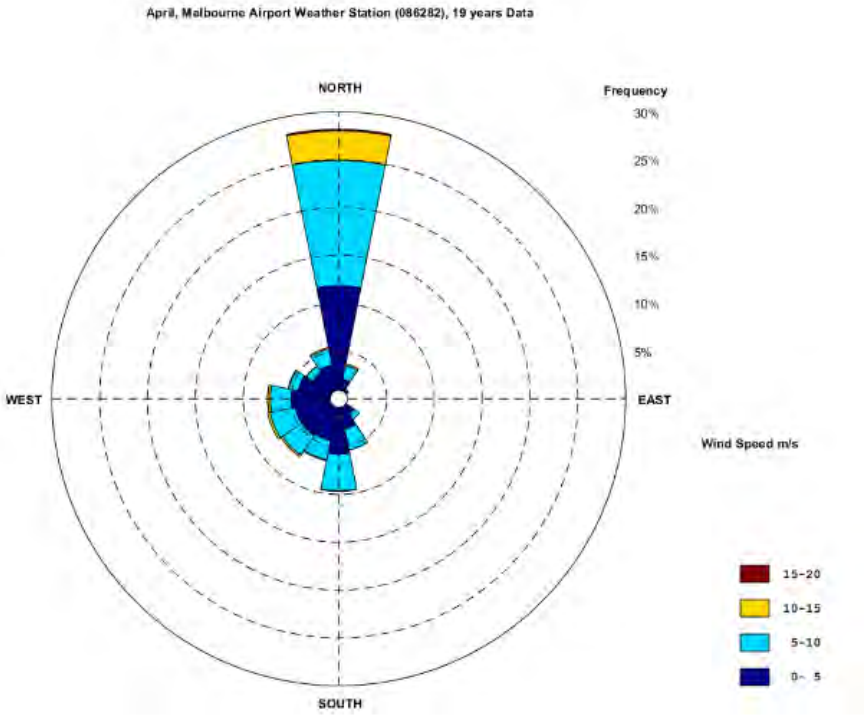
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NORTH
Frequency
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5%
WEST
EAST
SOUTH
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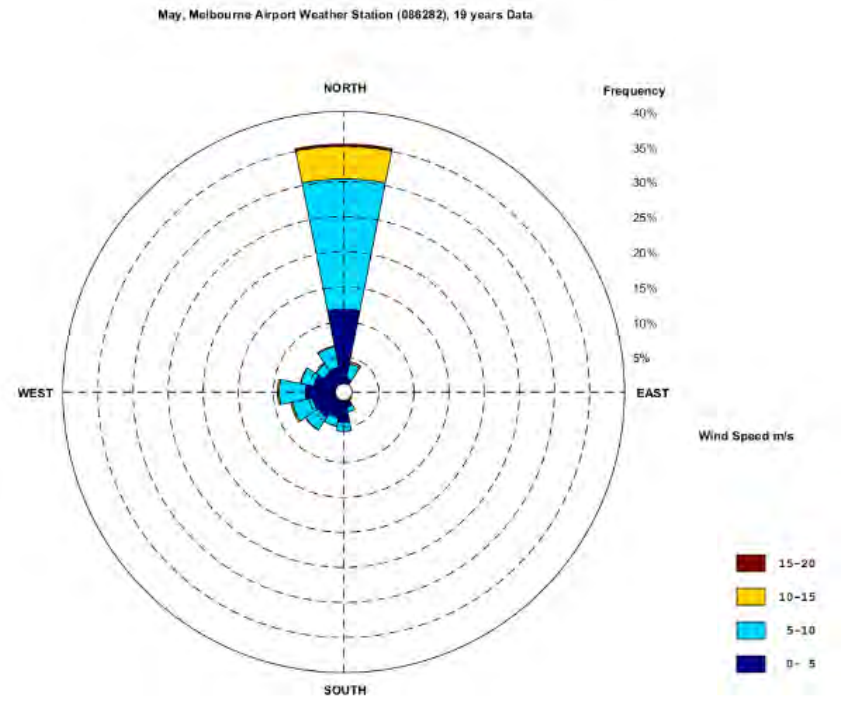
15-20
10-15
5-10
0- 5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20%
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WEST
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Wind Speed m/s
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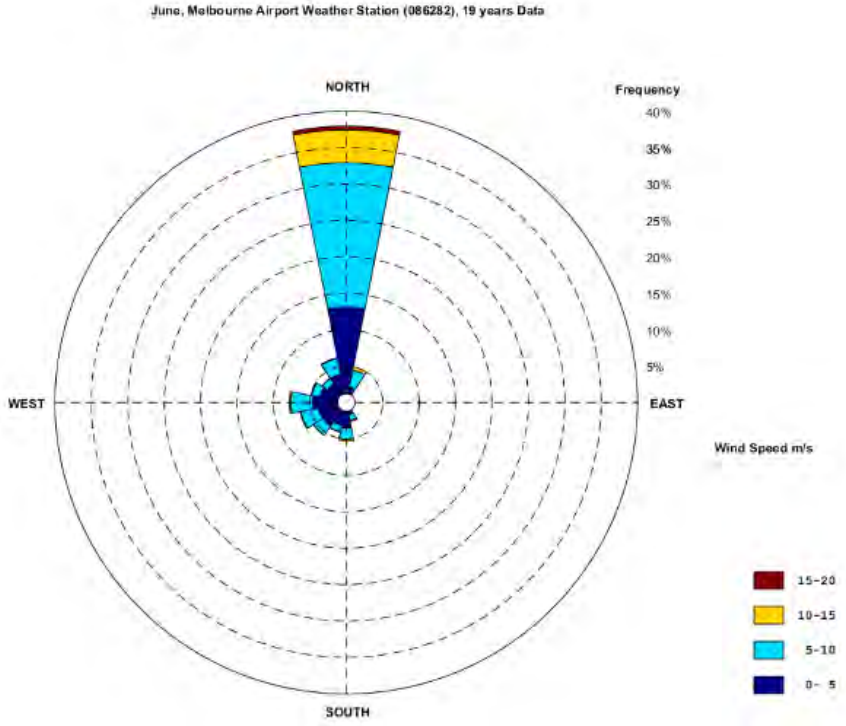
10-15
5-10
0- 5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NORTH
Frequency
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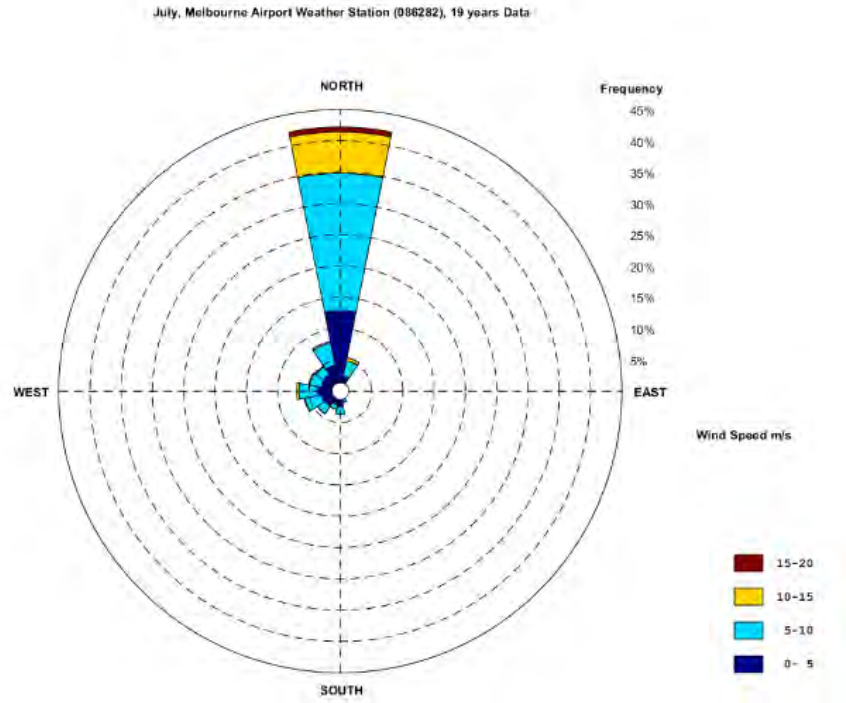
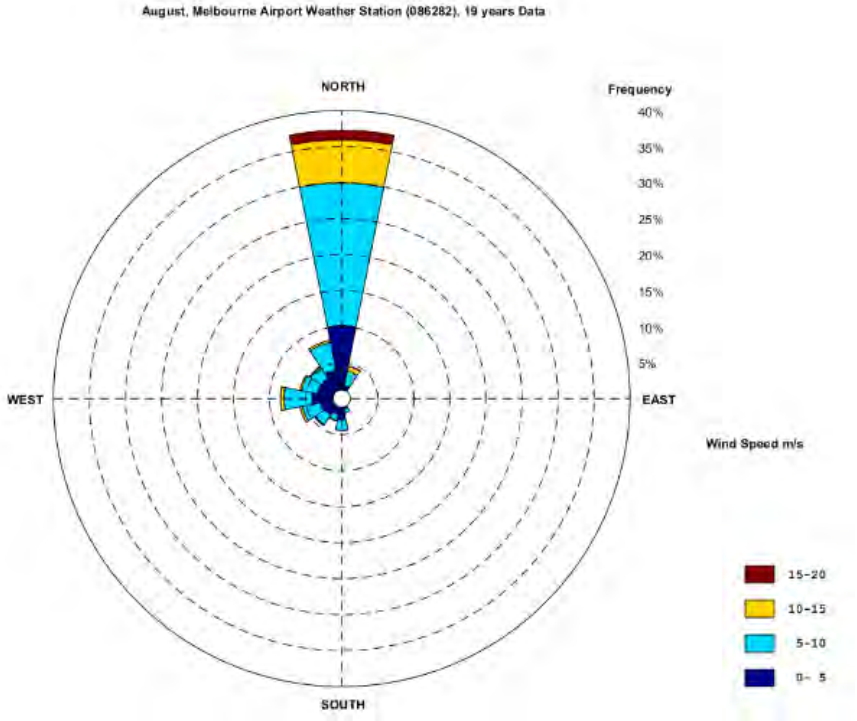
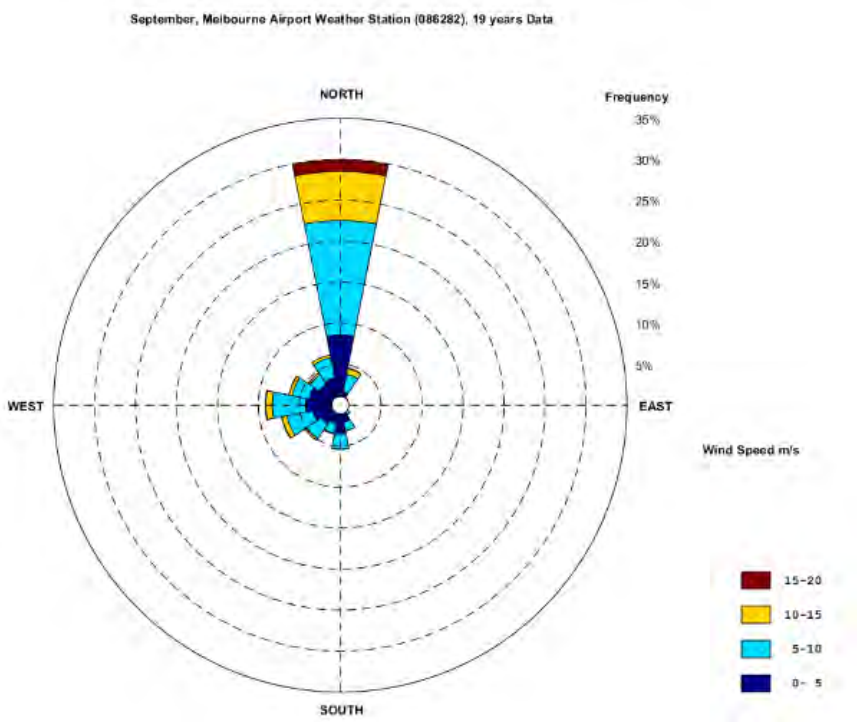
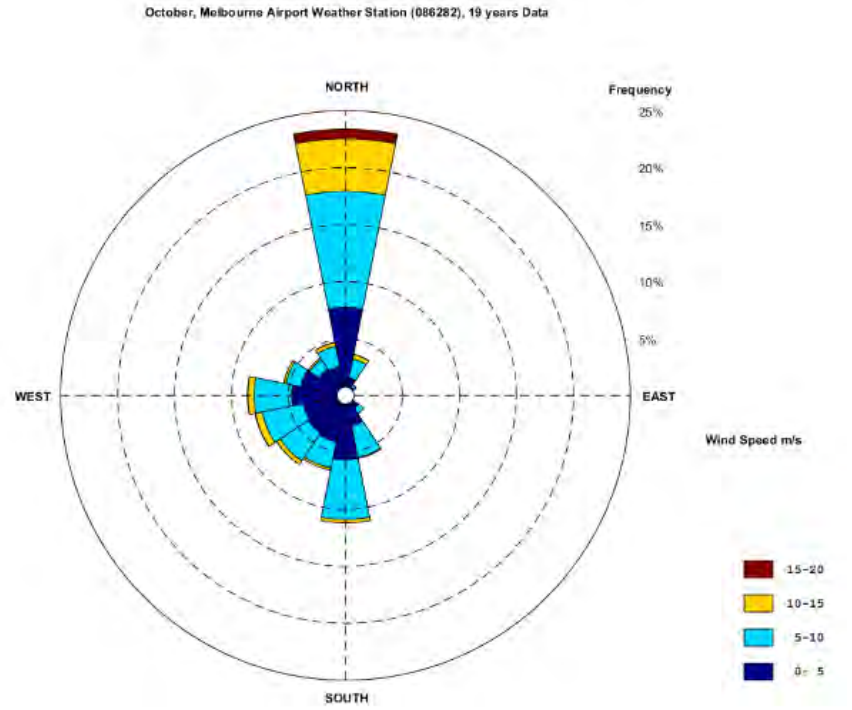
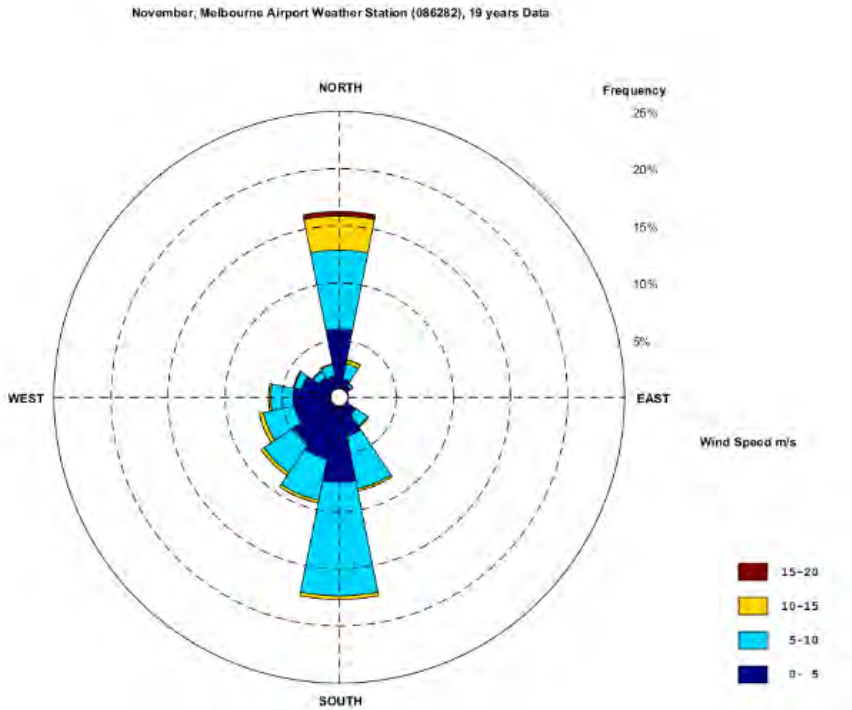
30%
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

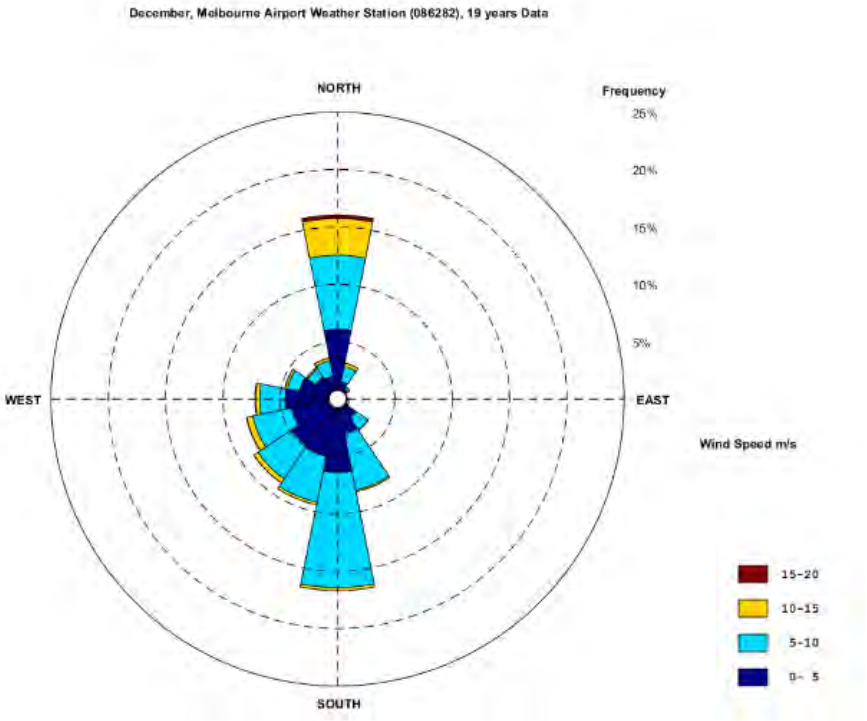

July, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
45%
40%
35%
30%
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


August, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
40%
35%
30%
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

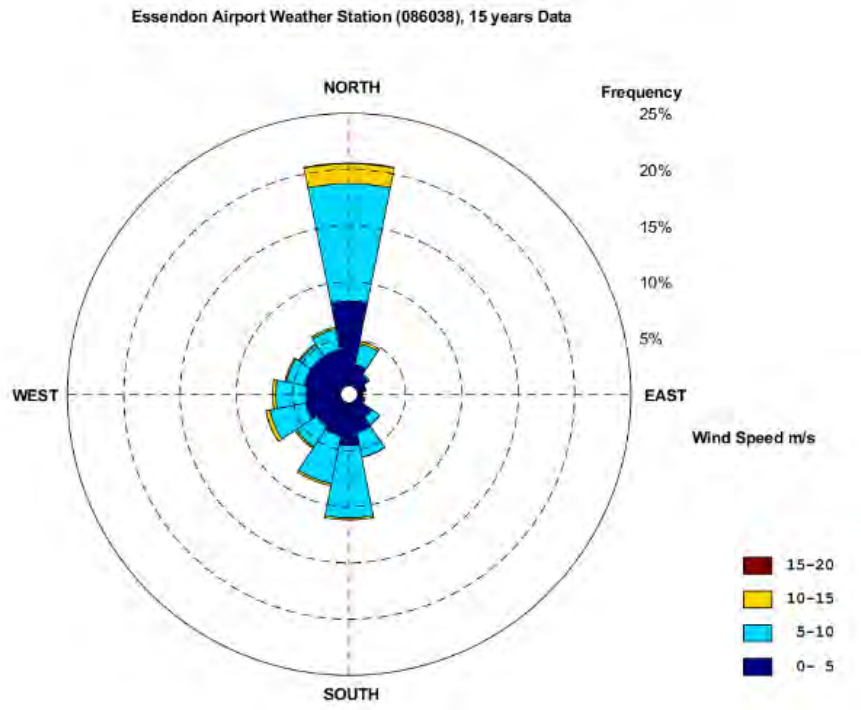

September, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
35%
30%
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

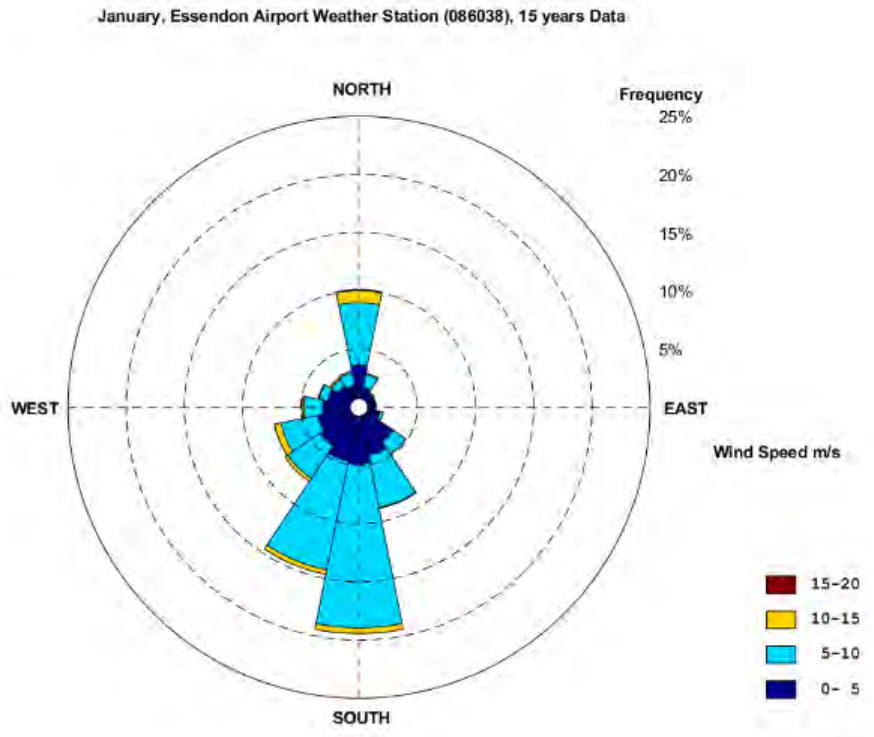

October, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


November, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

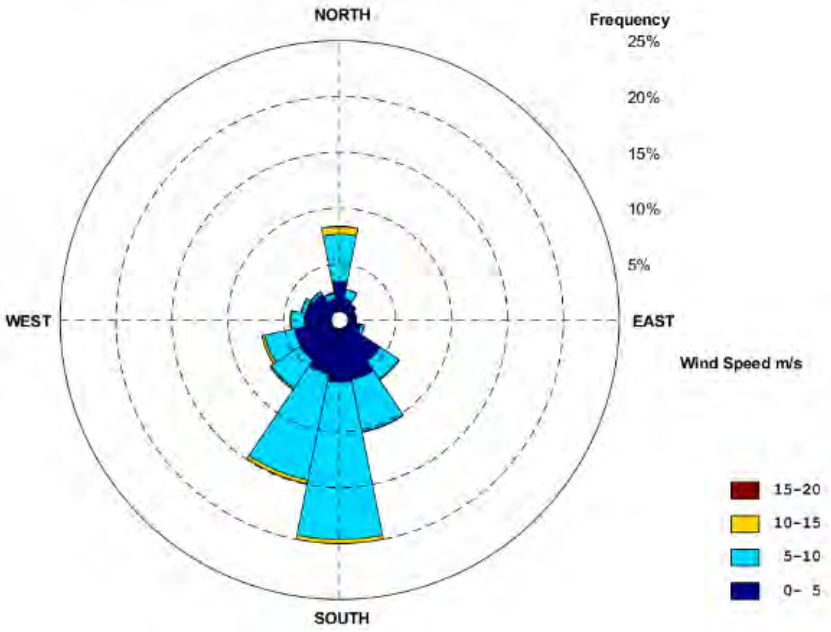

December, Melbourne Airport Weather Station (086282), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

ESSENDON AIRPORT

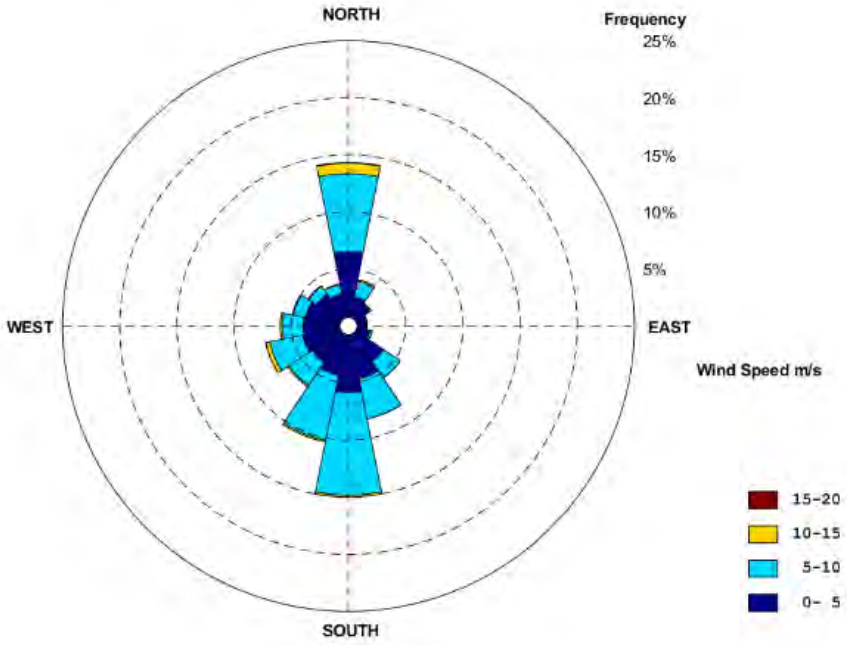

Essendon Airport Weather Station (086038), 15 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
Wind Speed m/s
15-20
10-15
5-10
0- 5
SOUTH


January, Essendon Airport Weather Station (086038), 15 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
Wind Speed m/s
15-20
10-15
5-10
0- 5
SOUTH

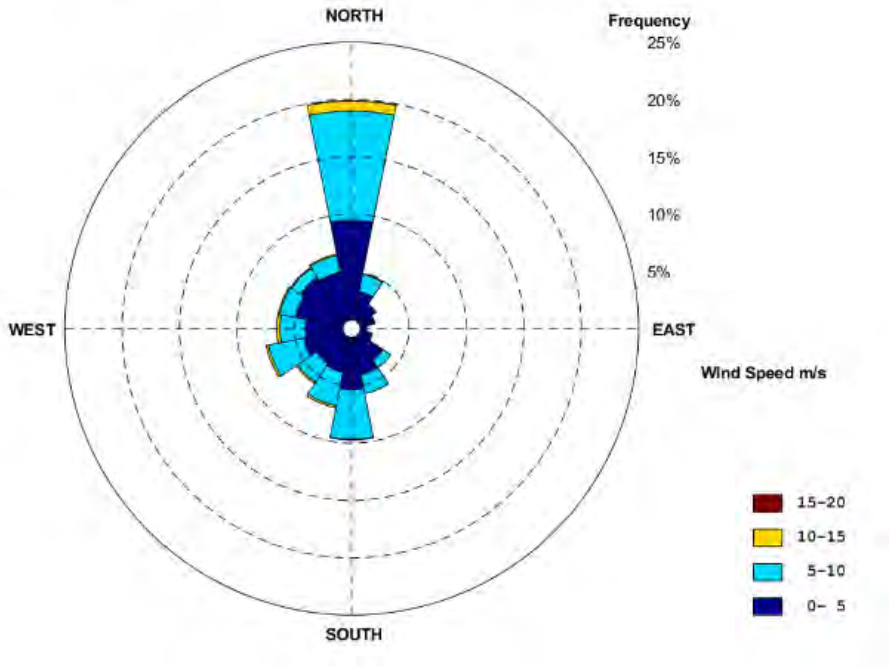
February, Essendon Airport Weather Station (086038), 15 years Data



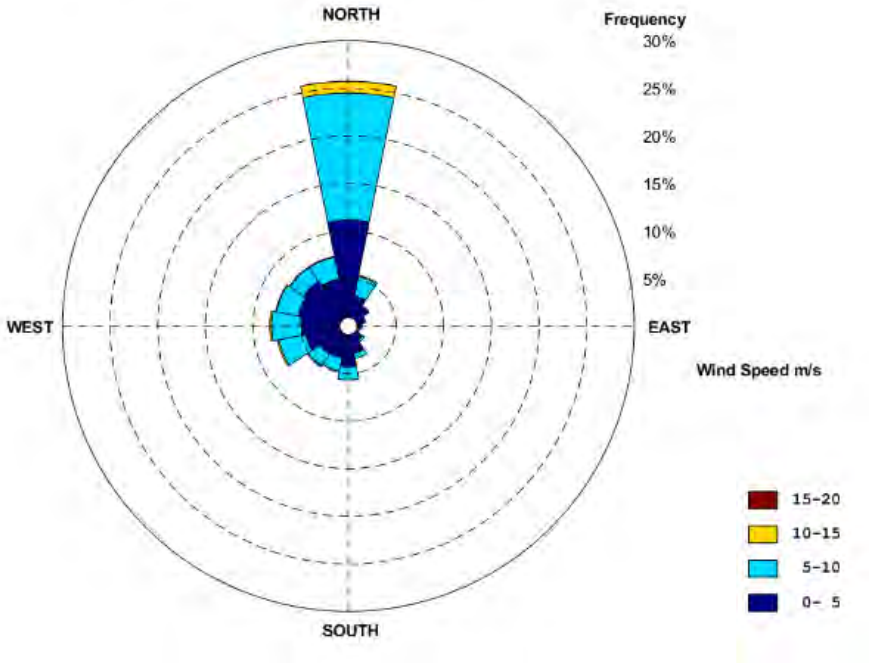
March, Essendon Airport Weather Station (086038), 15 years Data



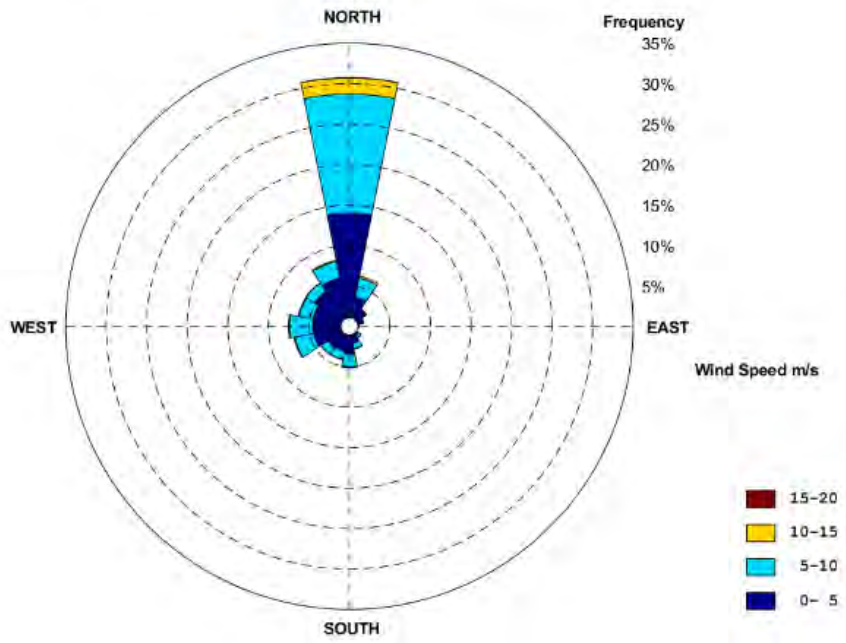
April, Essendon Airport Weather Station (086038), 15 years Data



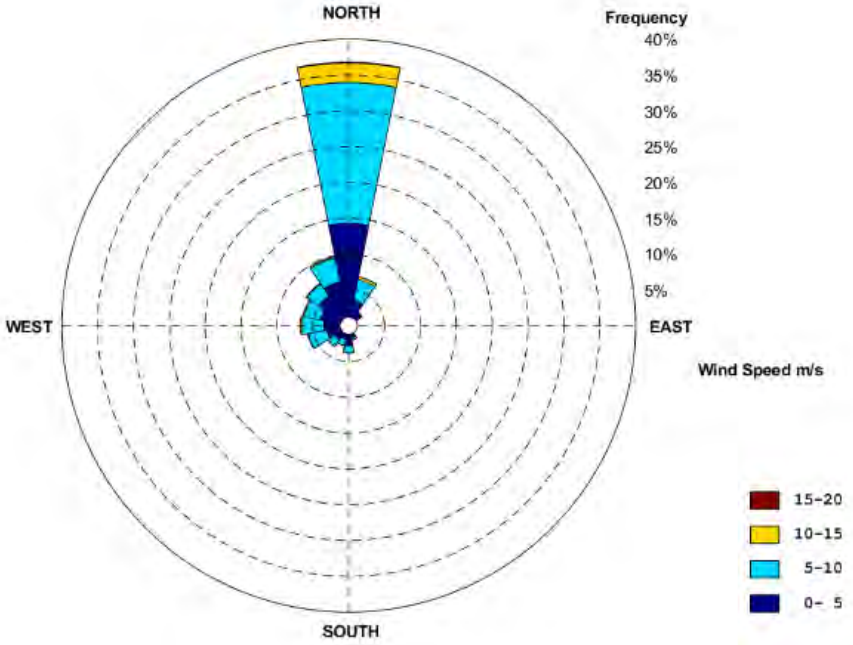
May, Essendon Airport Weather Station (086038), 15 years Data

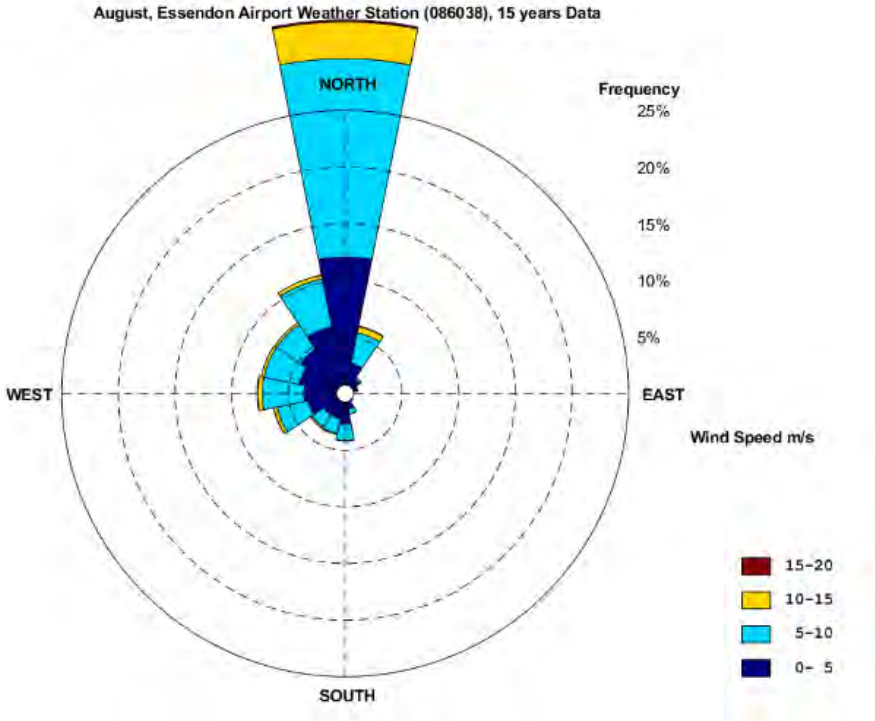


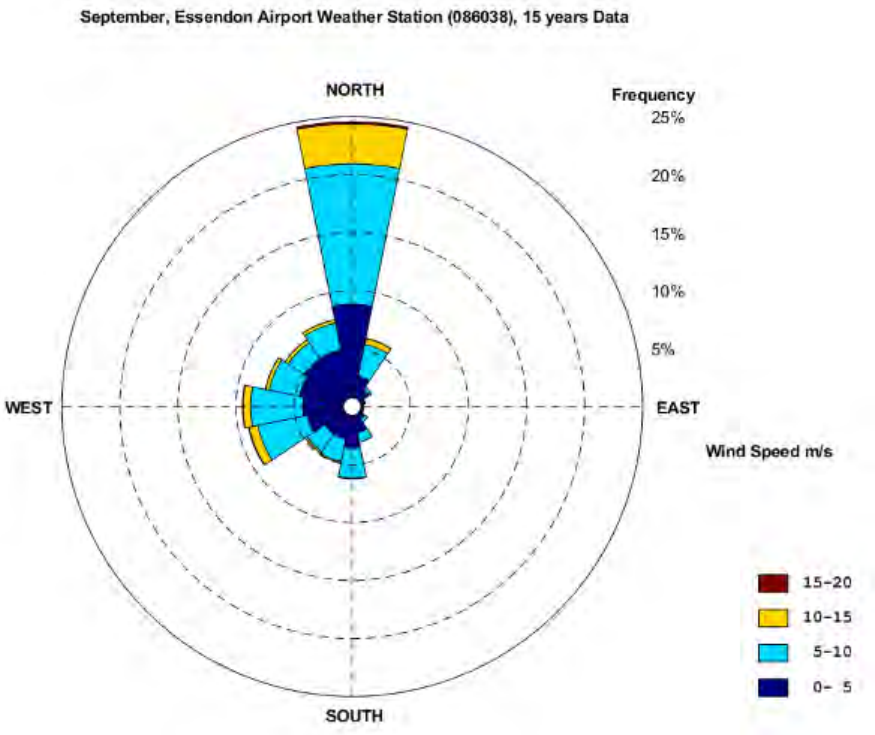
June, Essendon Airport Weather Station (086038), 15 years Data



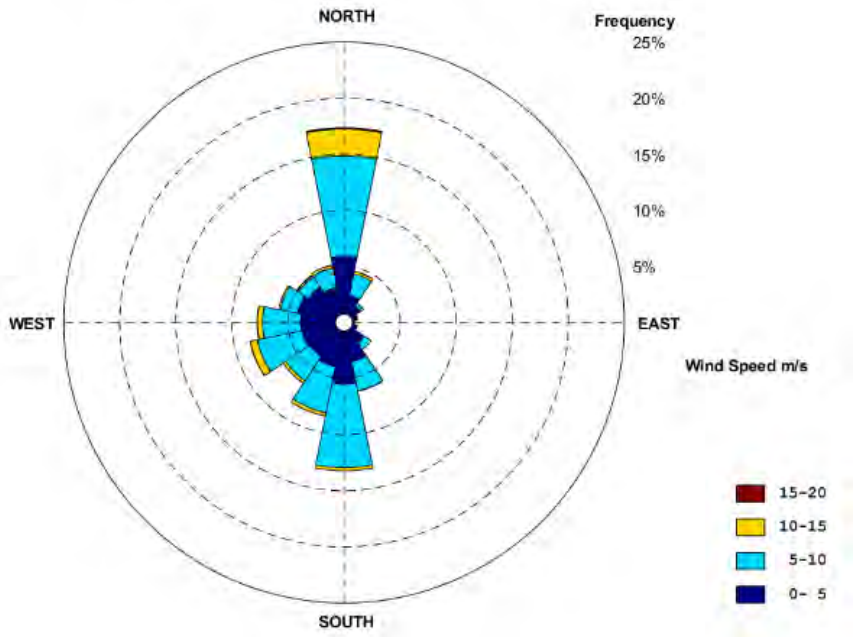
July, Essendon Airport Weather Station (086038), 15 years Data



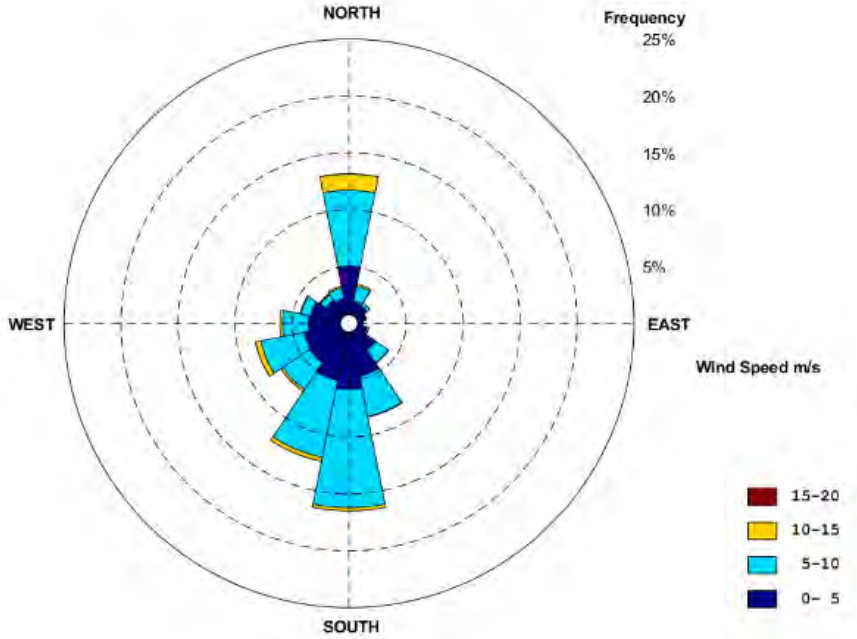

August, Essendon Airport Weather Station (086038), 15 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
Wind Speed m/s
15-20
10-15
5-10
0- 5
SOUTH

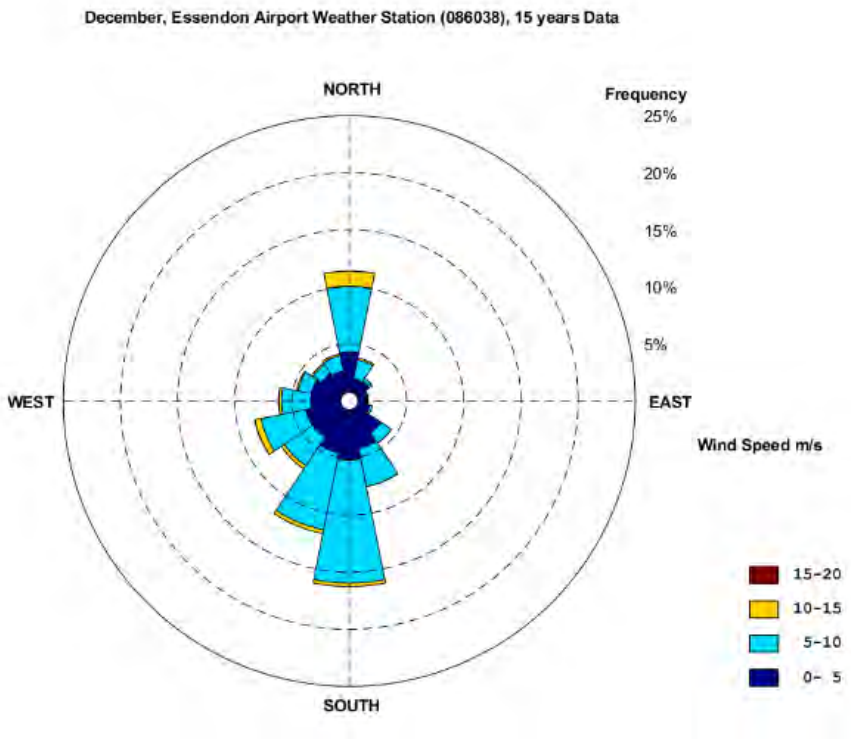

September, Essendon Airport Weather Station (086038), 15 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
Wind Speed m/s
15-20
10-15
5-10
0- 5
SOUTH

October, Essendon Airport Weather Station (086038), 15 years Data

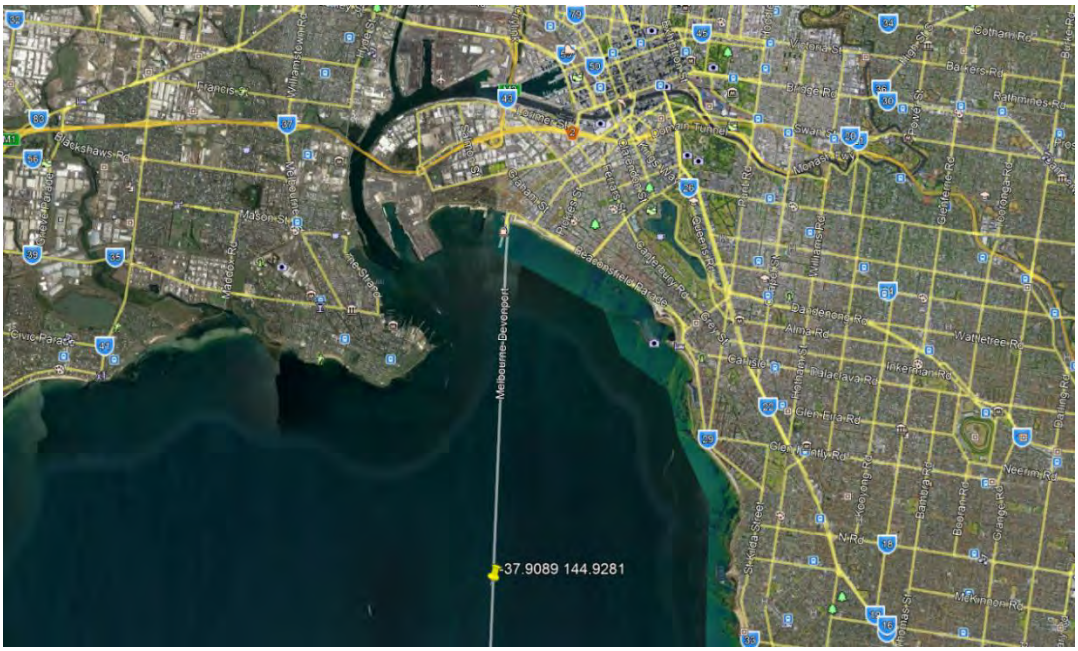


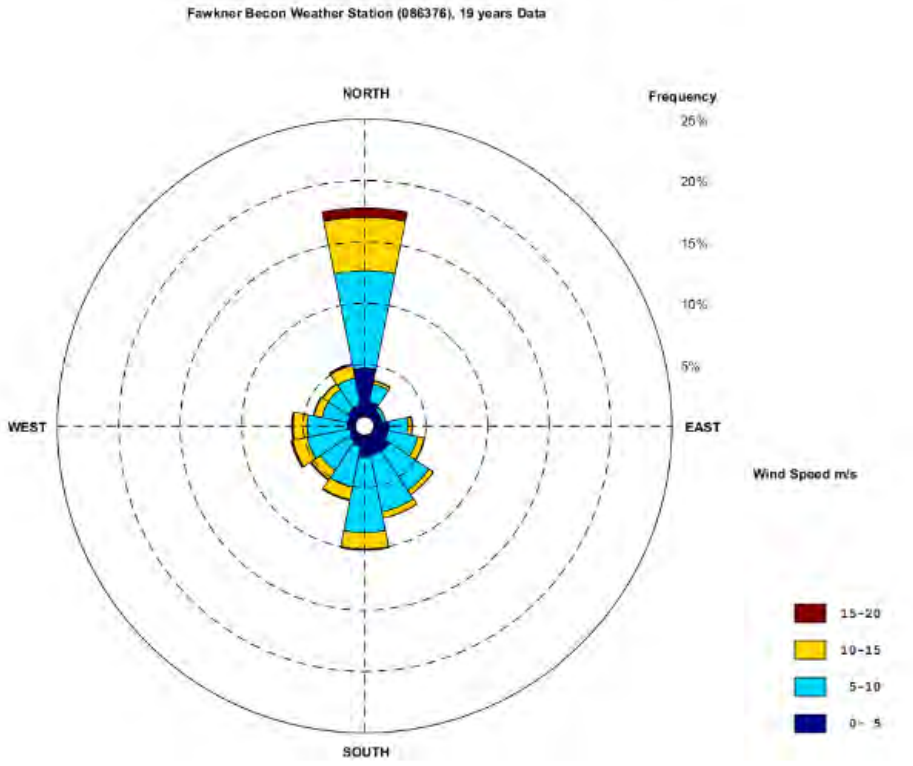
November, Essendon Airport Weather Station (086038), 15 years Data

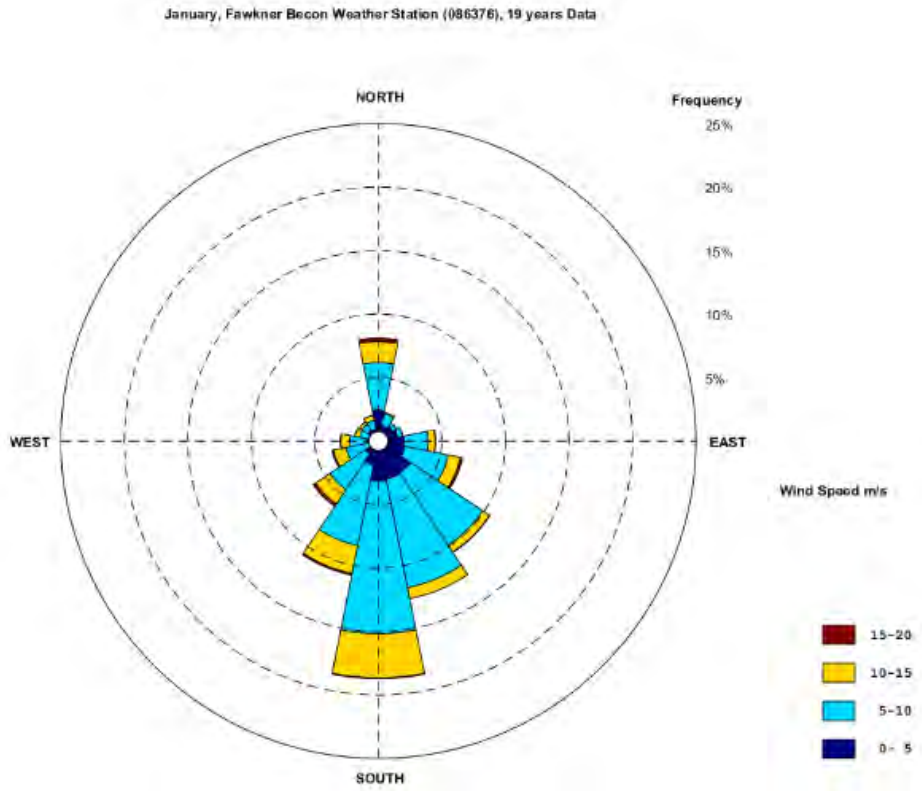


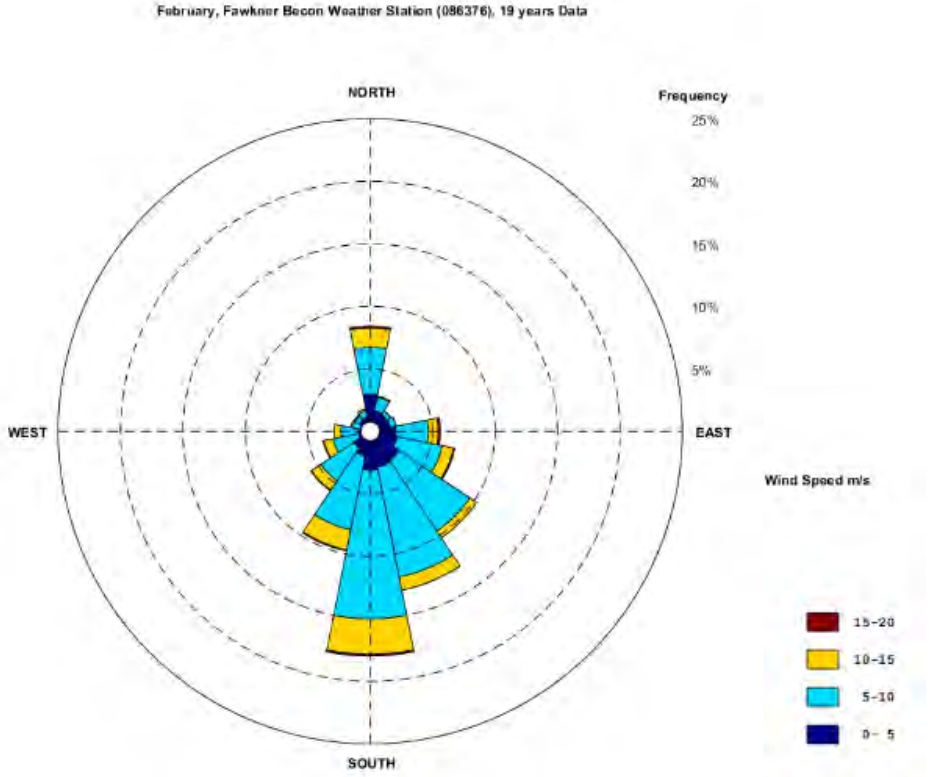

December, Essendon Airport Weather Station (086038), 15 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
Wind Speed m/s
15-20
10-15
5-10
0- 5
SOUTH

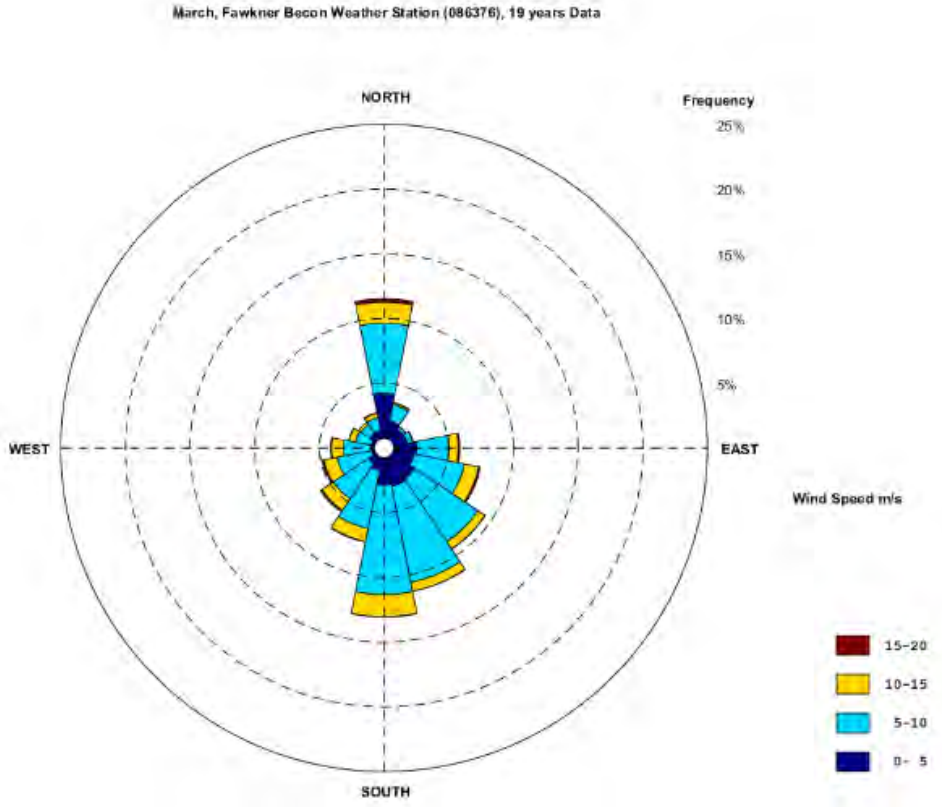
FAWKNER BEACON



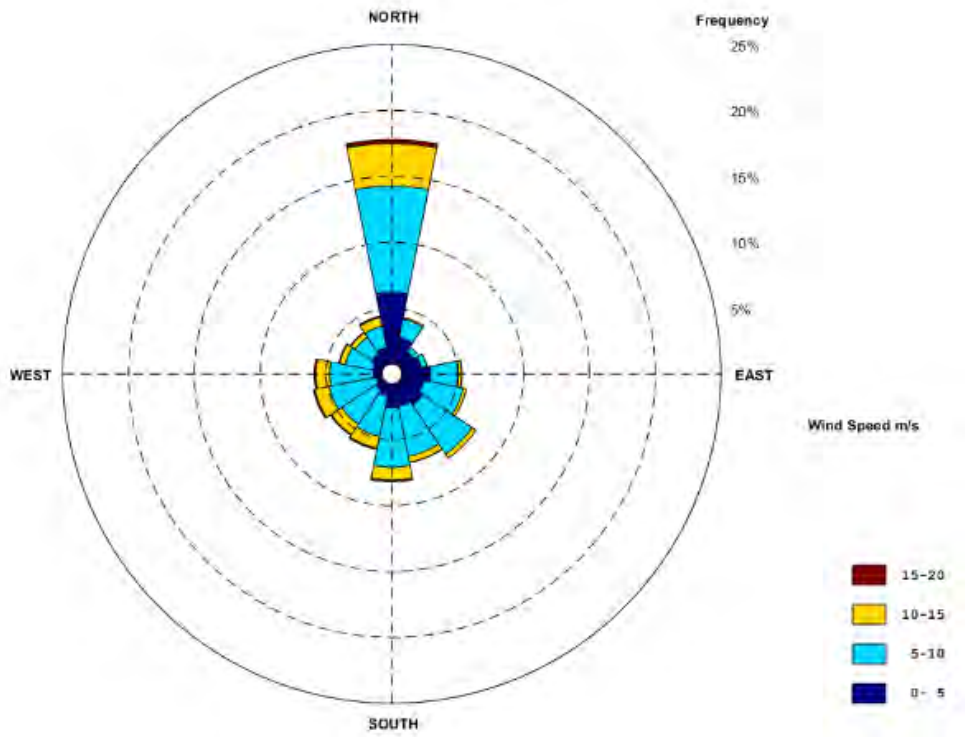

Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


January, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

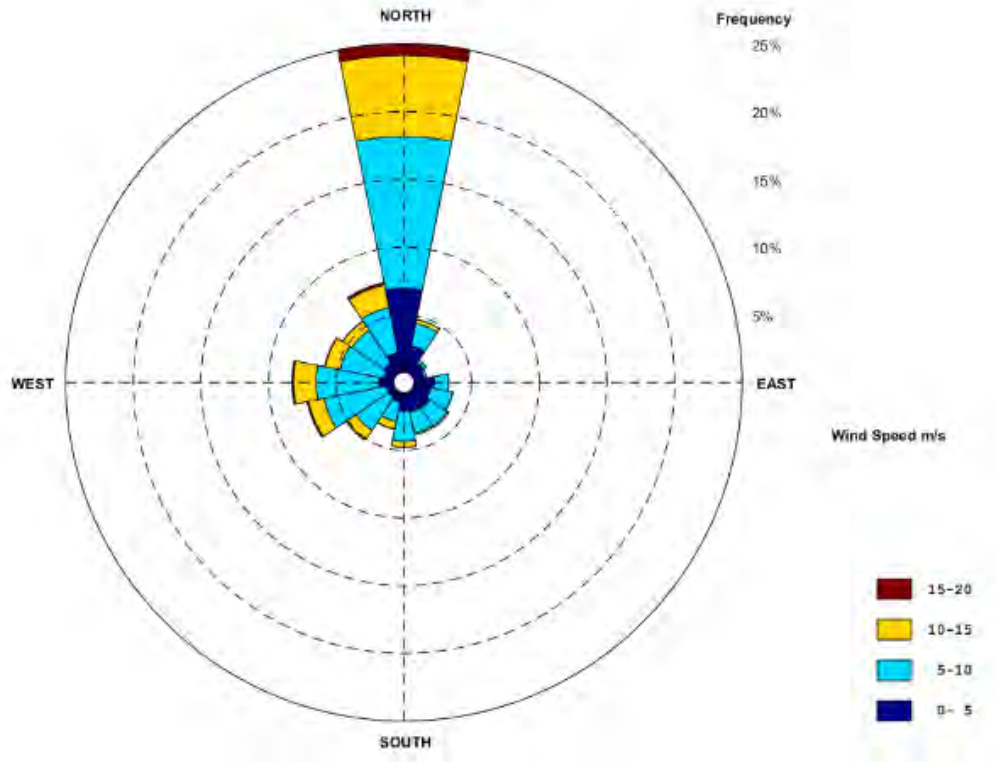

February, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


March, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

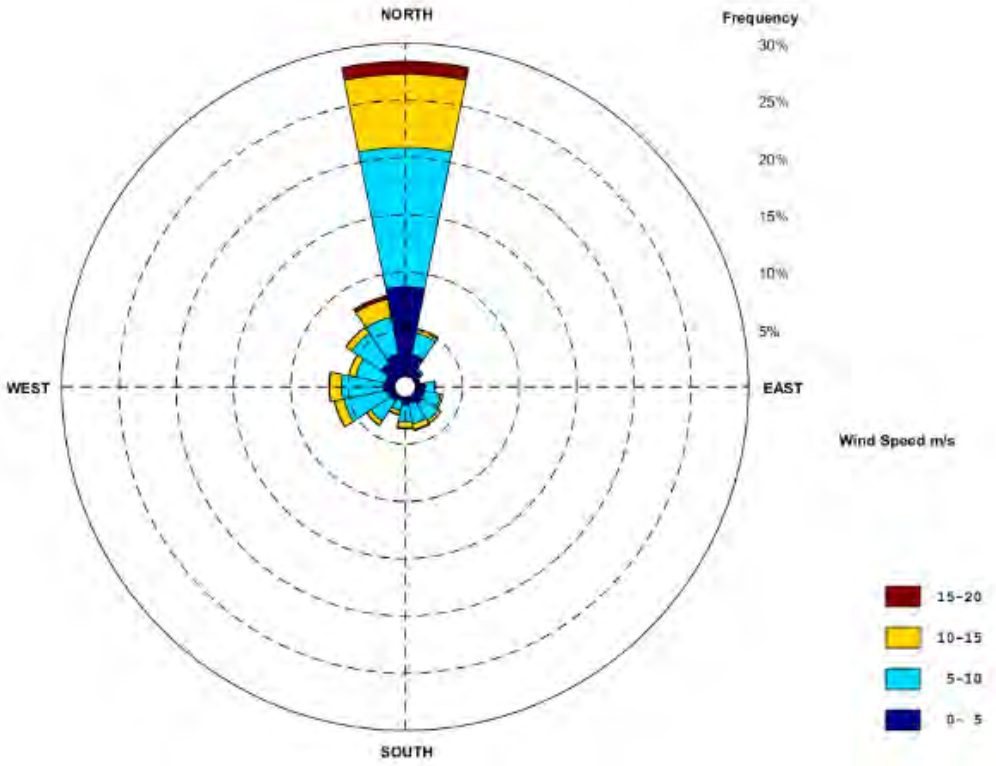
April, Fawkner Becon Weather Station (086376), 19 years Data



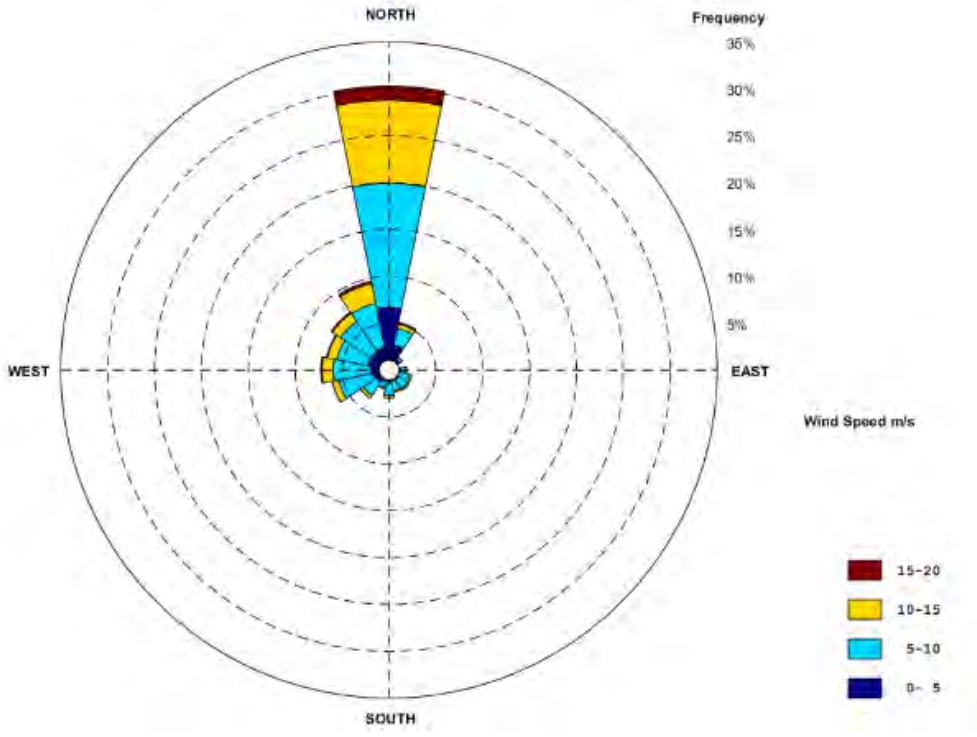
May, Fawkner Becon Weather Station (086376), 19 years Data

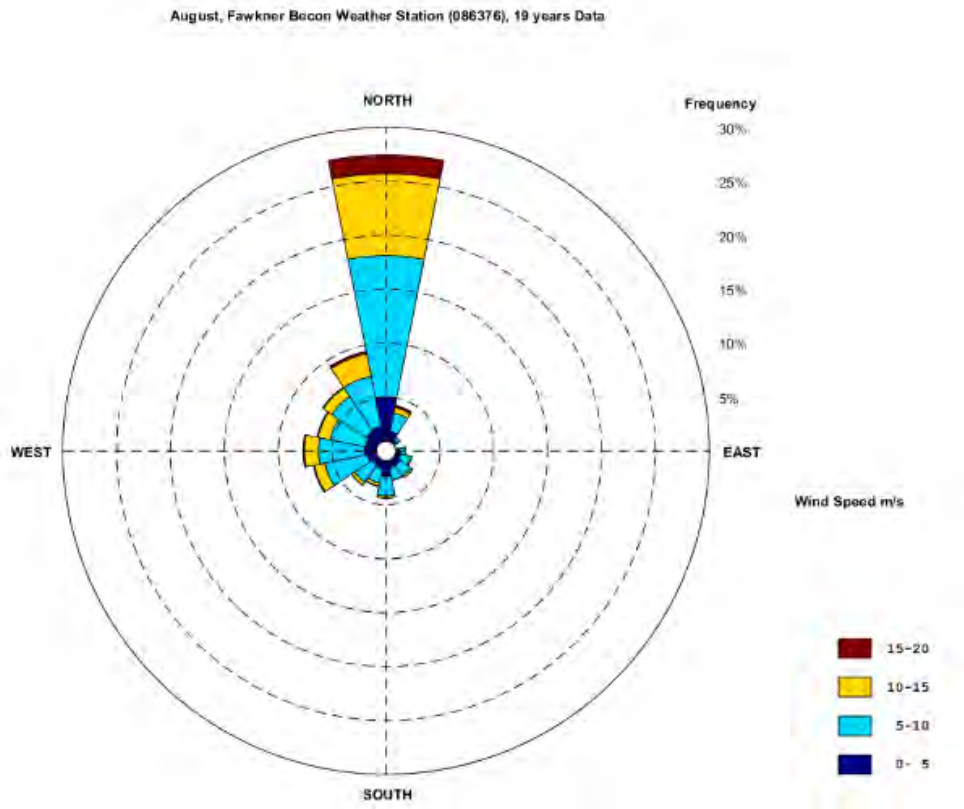


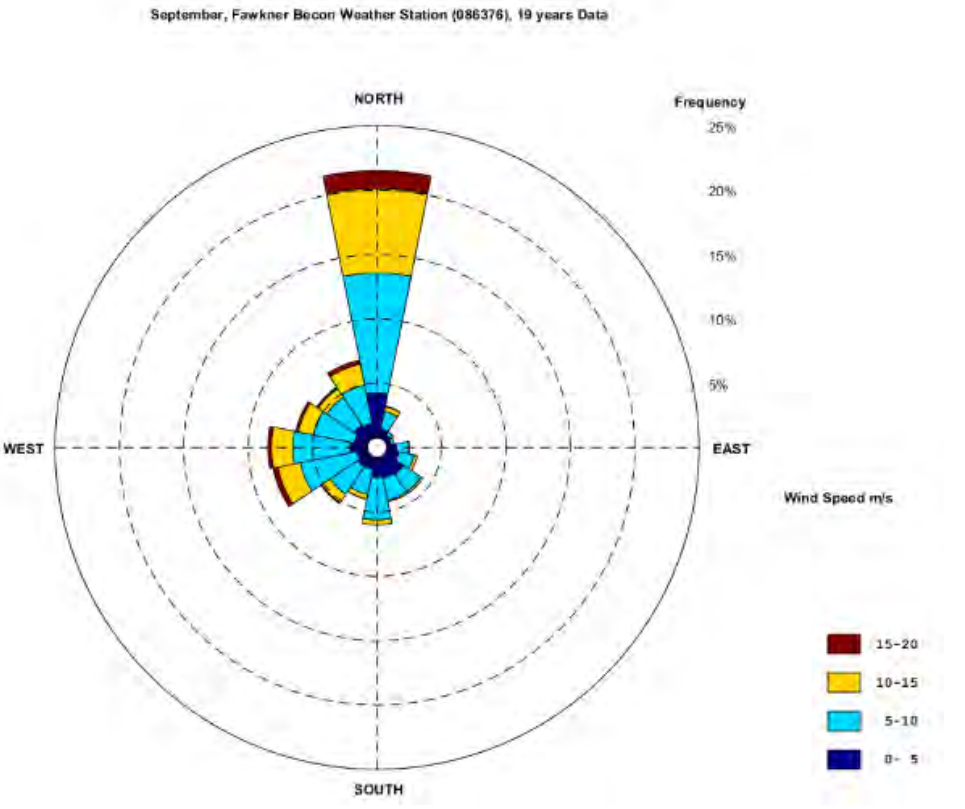
June, Fawkner Becon Weather Station (086376), 19 years Data

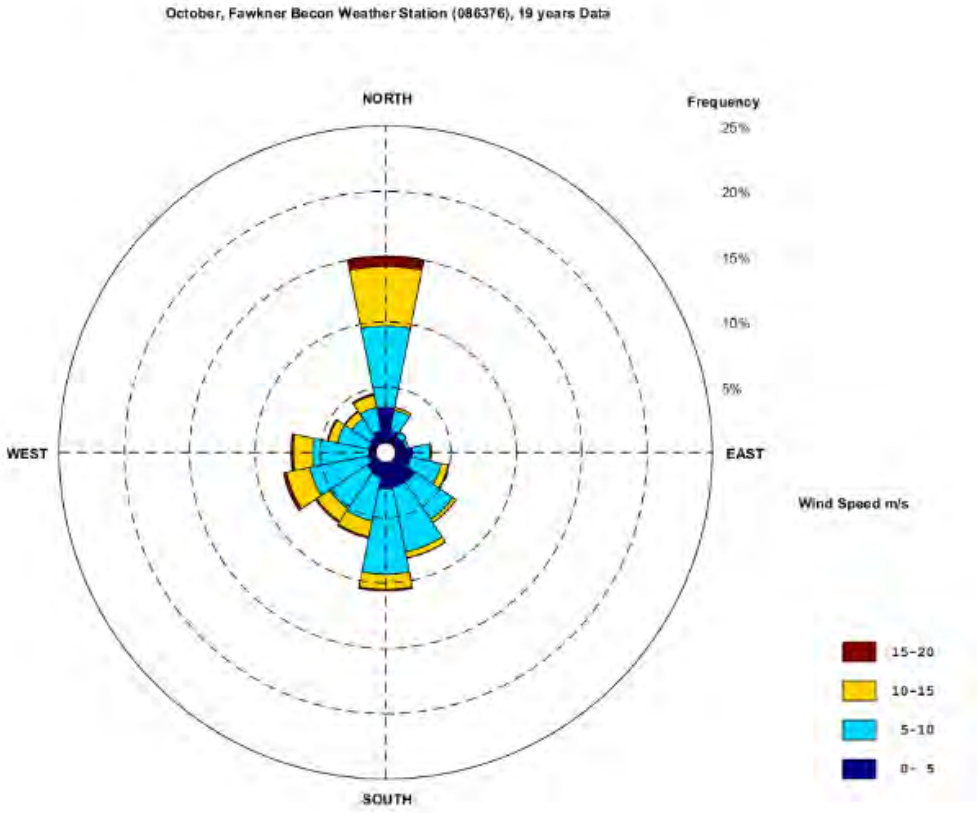


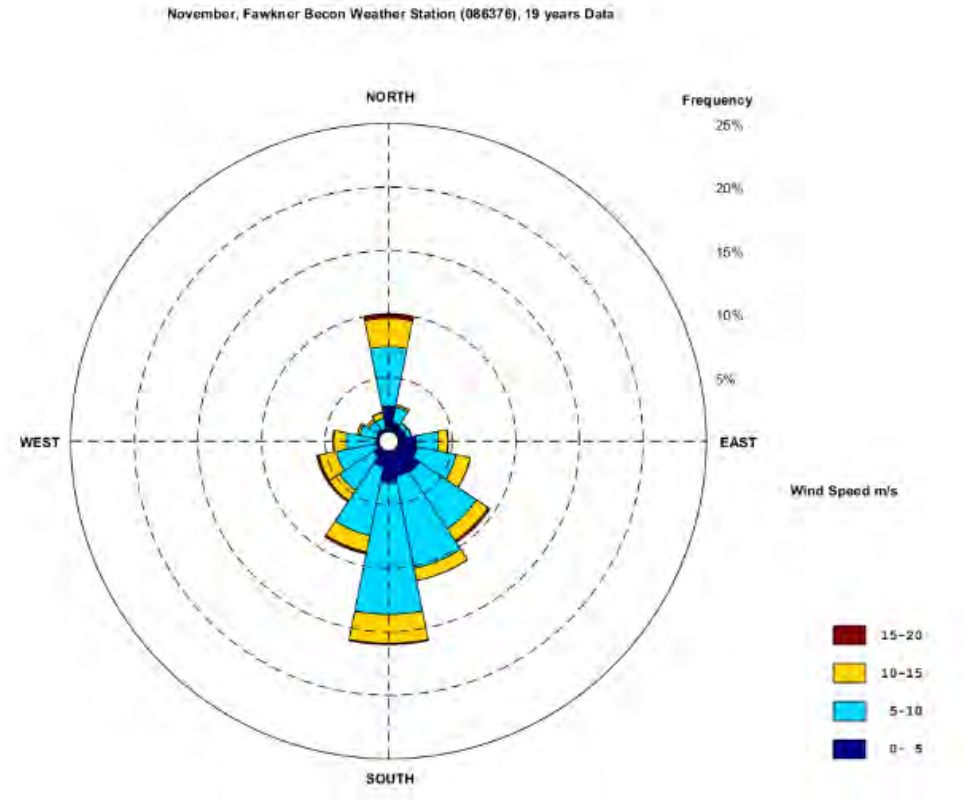
July, Fawkner Becon Weather Station (086376), 19 years Data

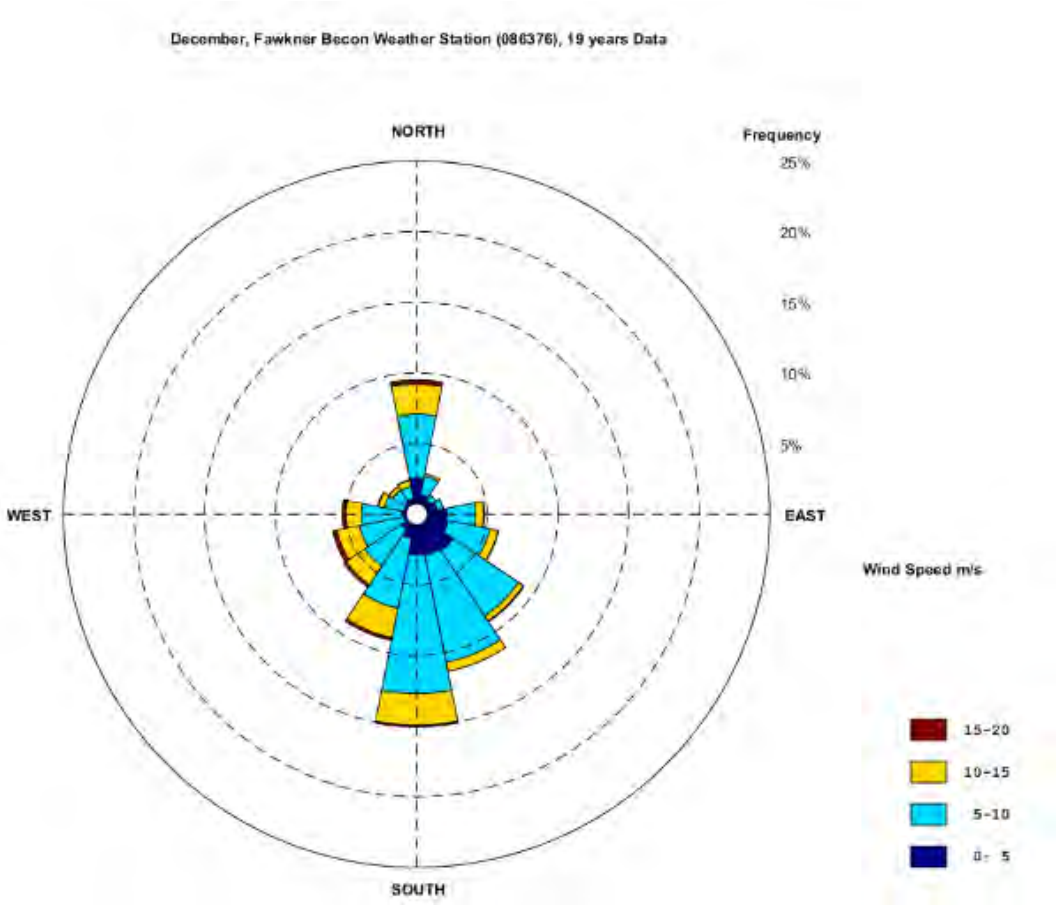



August, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
30%
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


September, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5


October, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

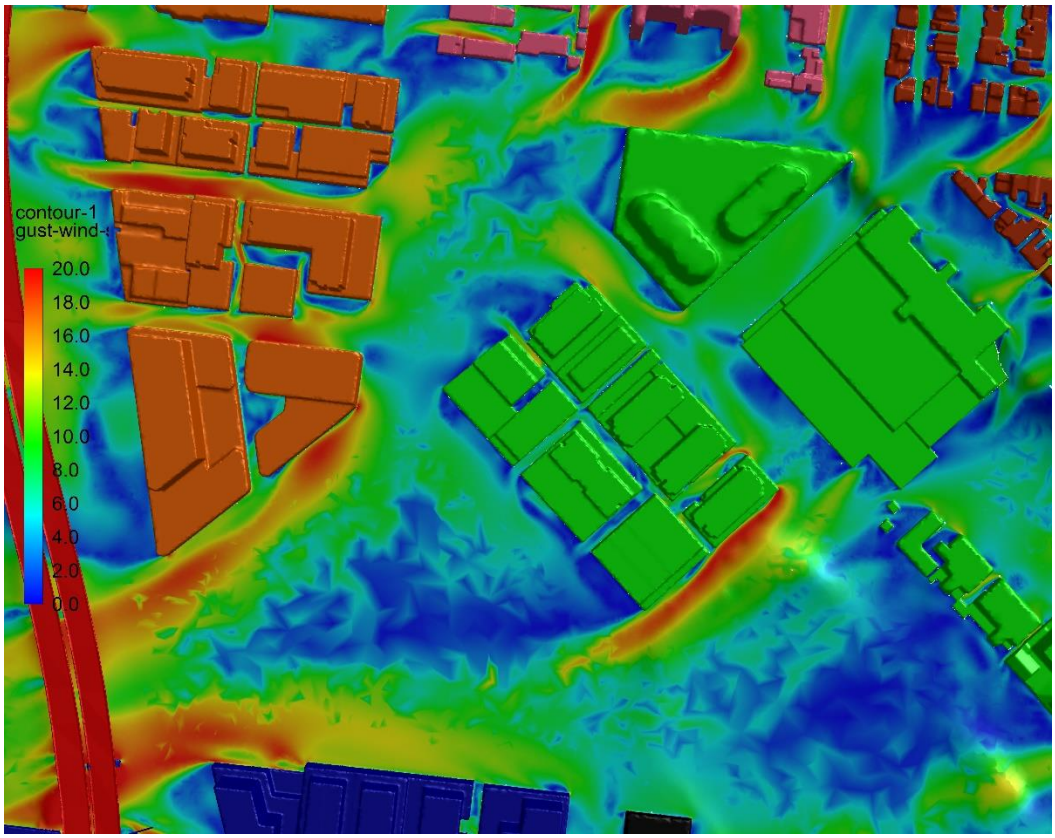

November, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

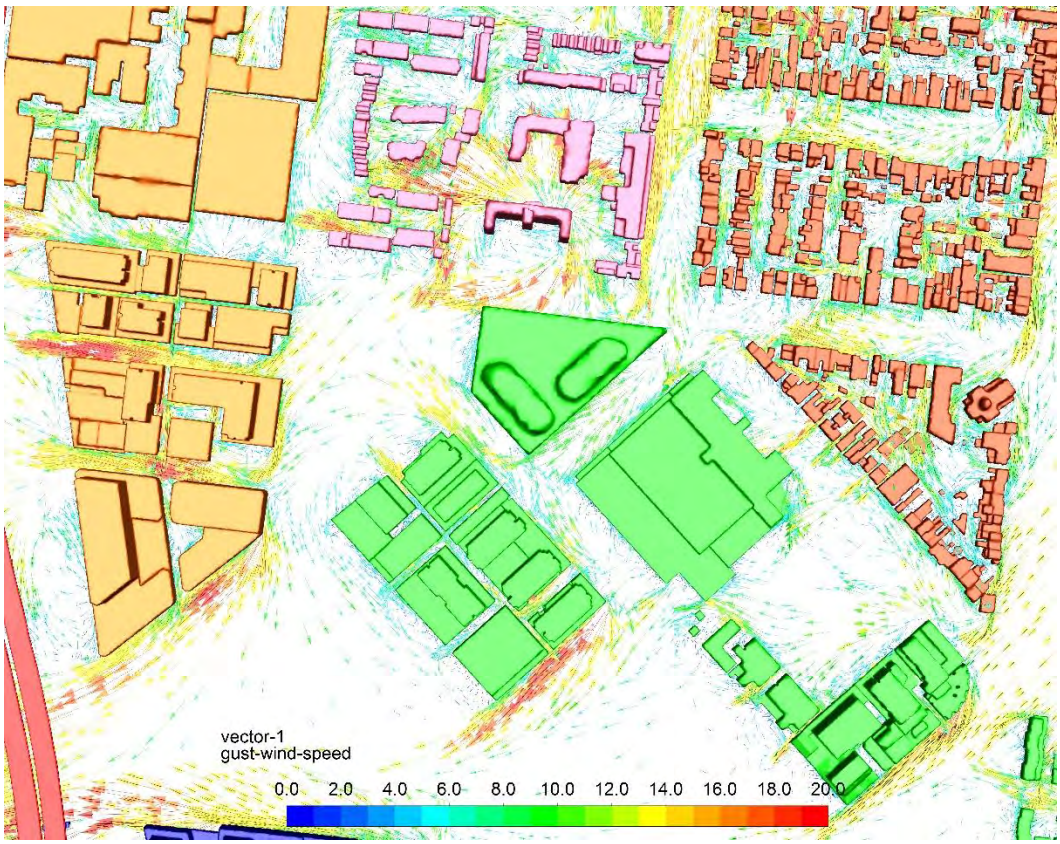

December, Fawkner Becon Weather Station (086376), 19 years Data
NORTH
Frequency
25%
20%
15%
10%
5%
WEST
EAST
SOUTH
Wind Speed m/s
15-20
10-15
5-10
0- 5

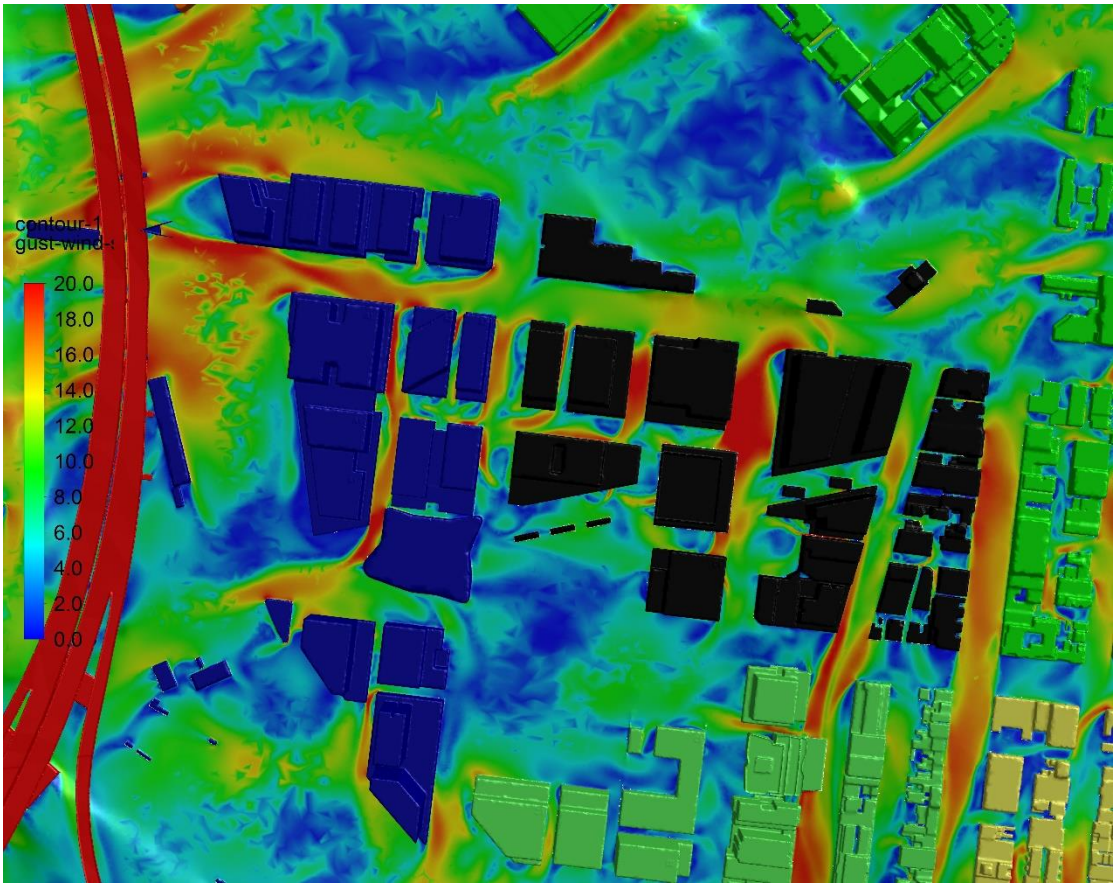
APPENDIX B

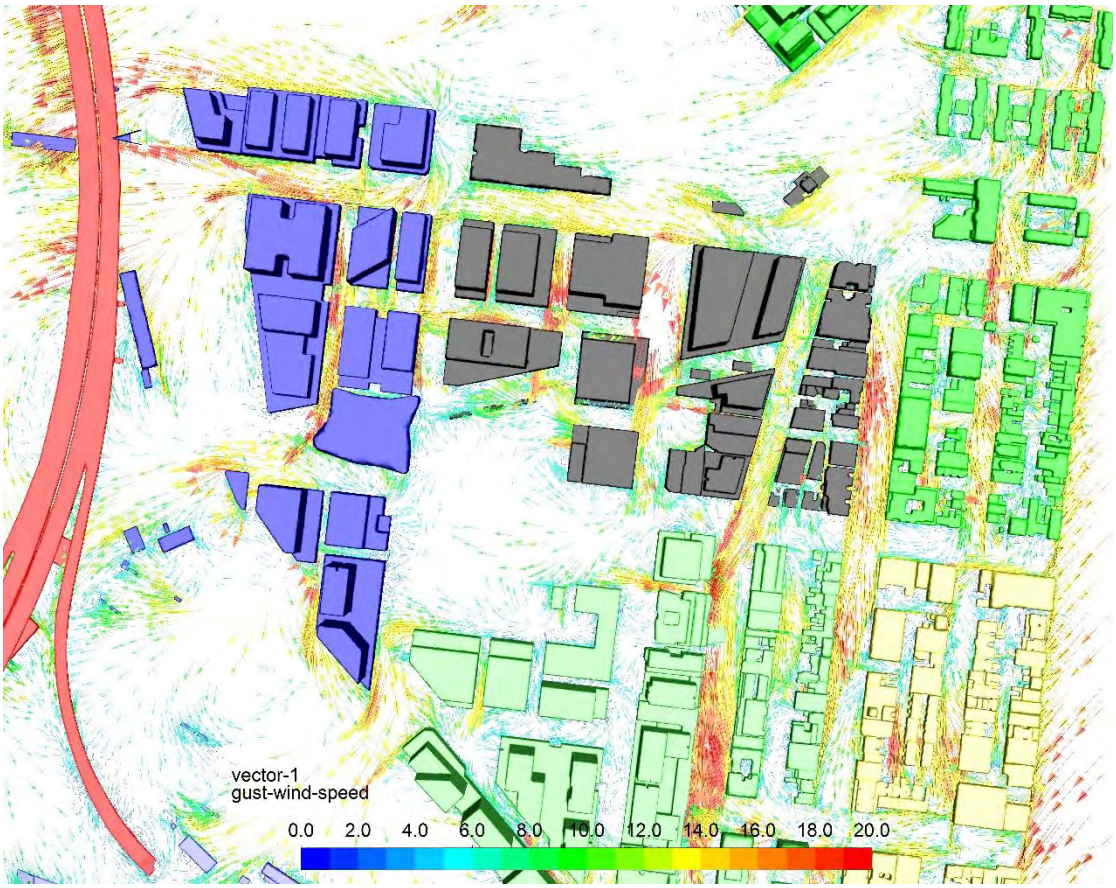
Contour and Vector Plots of the Gust Mean Wind Speed for NE, E, SE, SW and NW directions

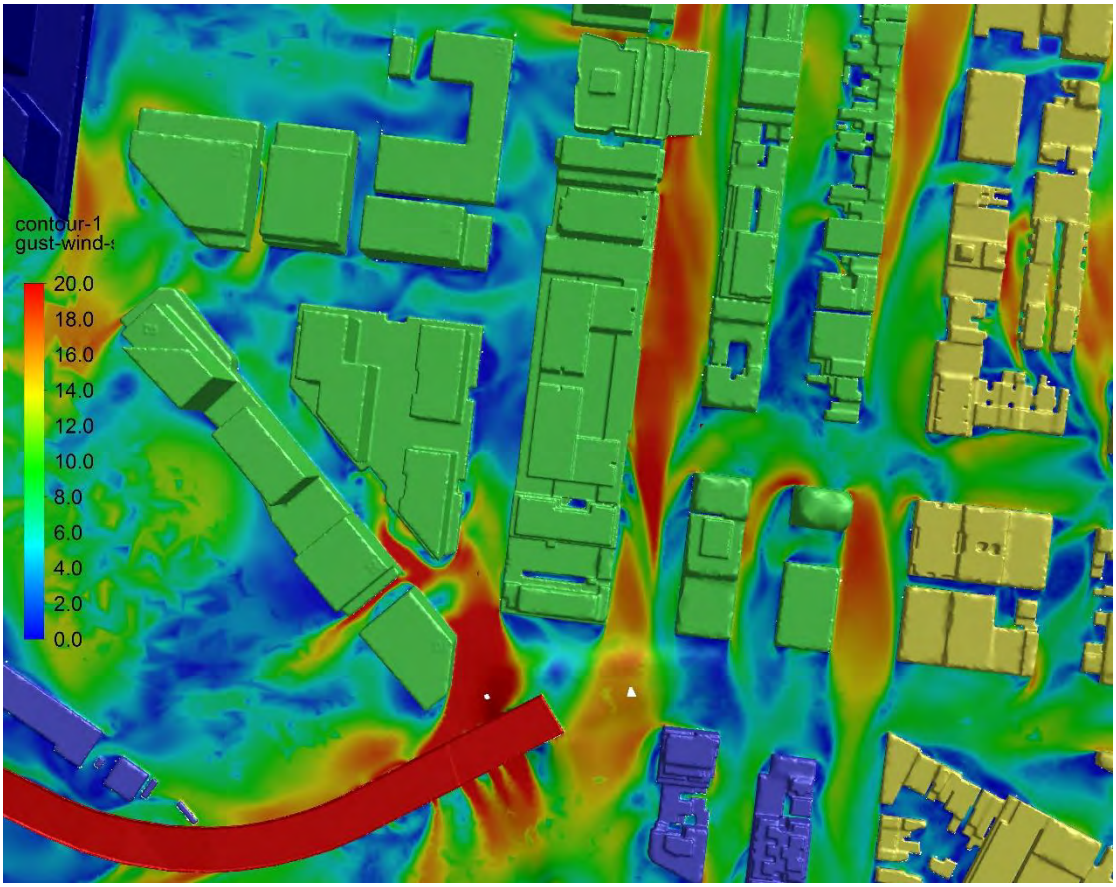
North East:

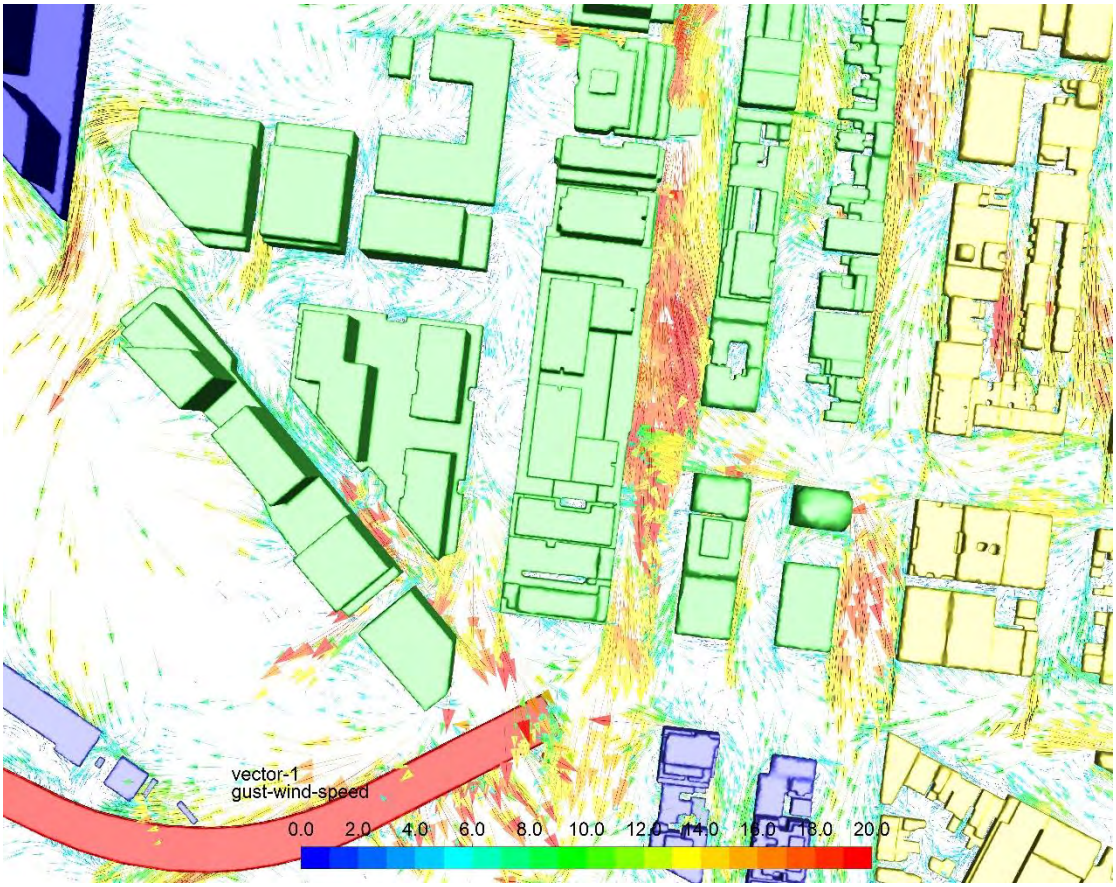

contour-1
gust-wind-s
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0


vector-1
gust-wind-speed
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0

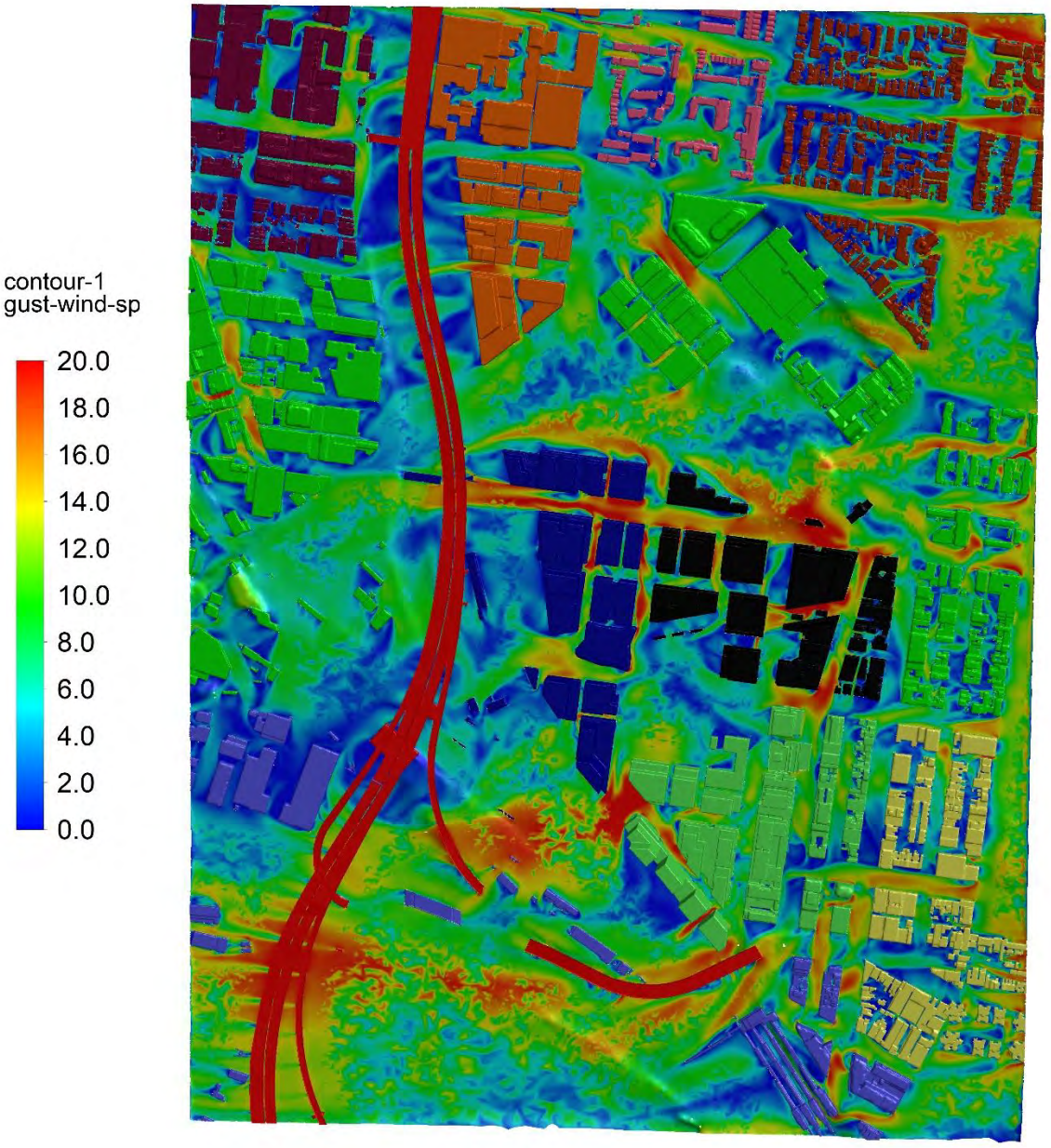

contour-1
gust-wind-s
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0

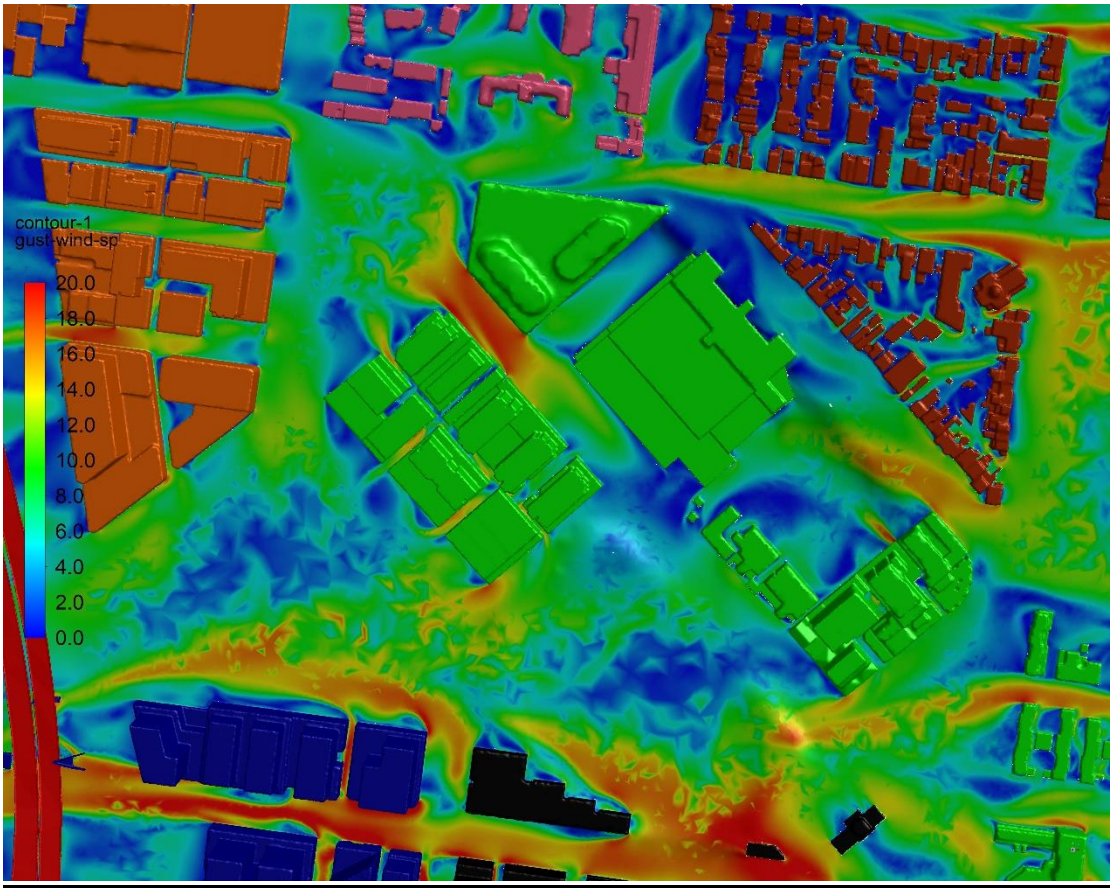

vector-1
gust-wind-speed
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0

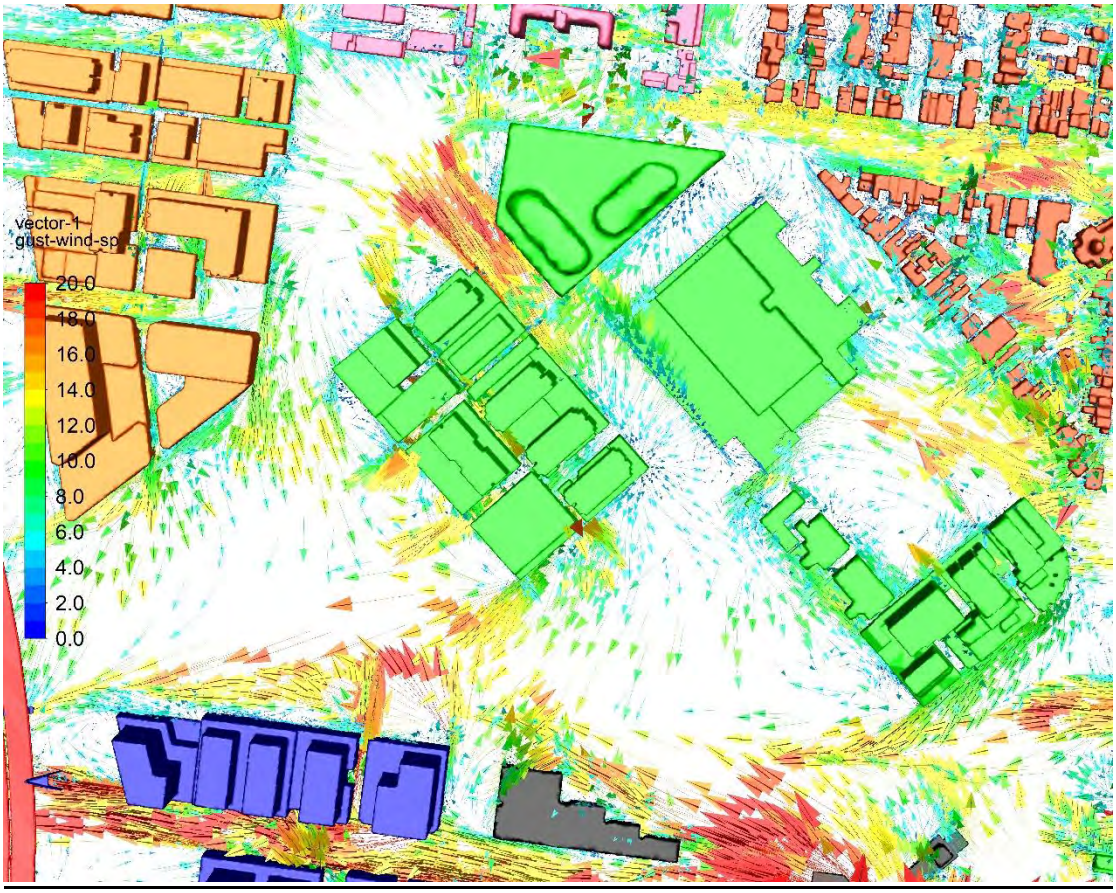

contour-1
gust-wind-s
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0

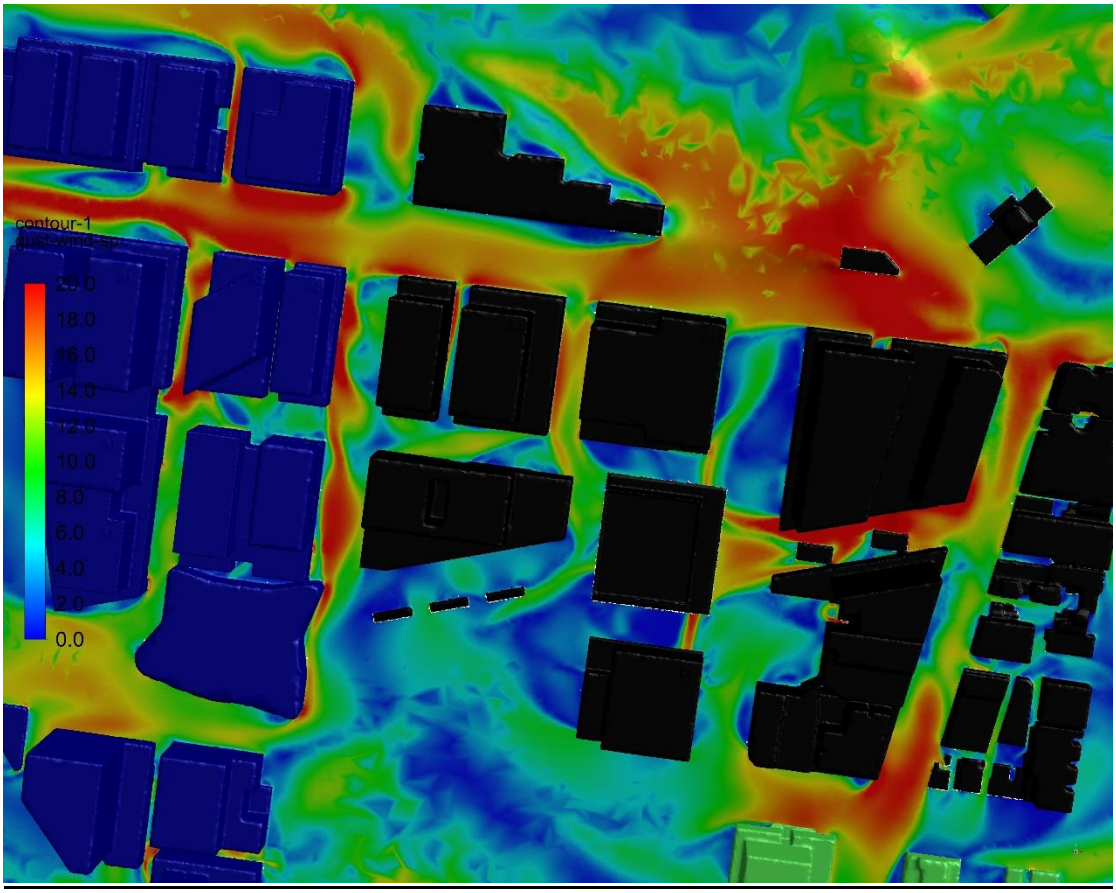

vector-1
gust-wind-speed
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0

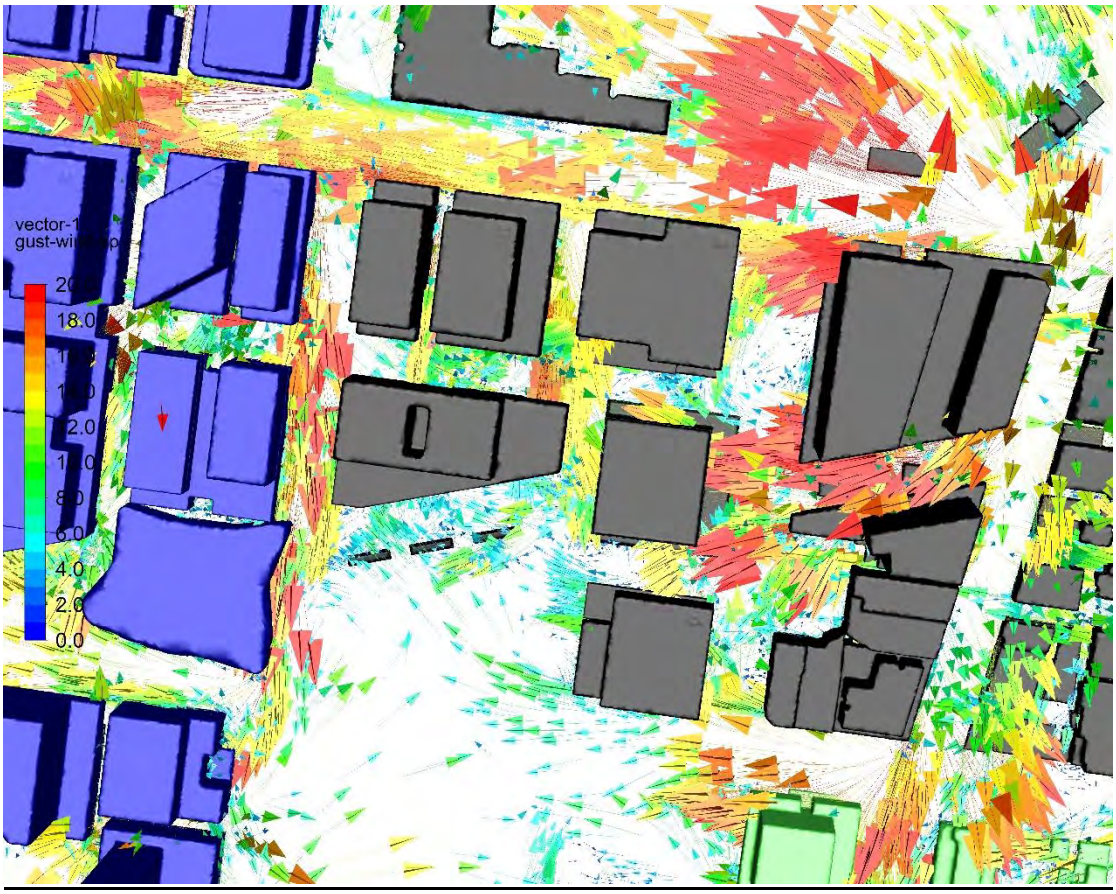
East:

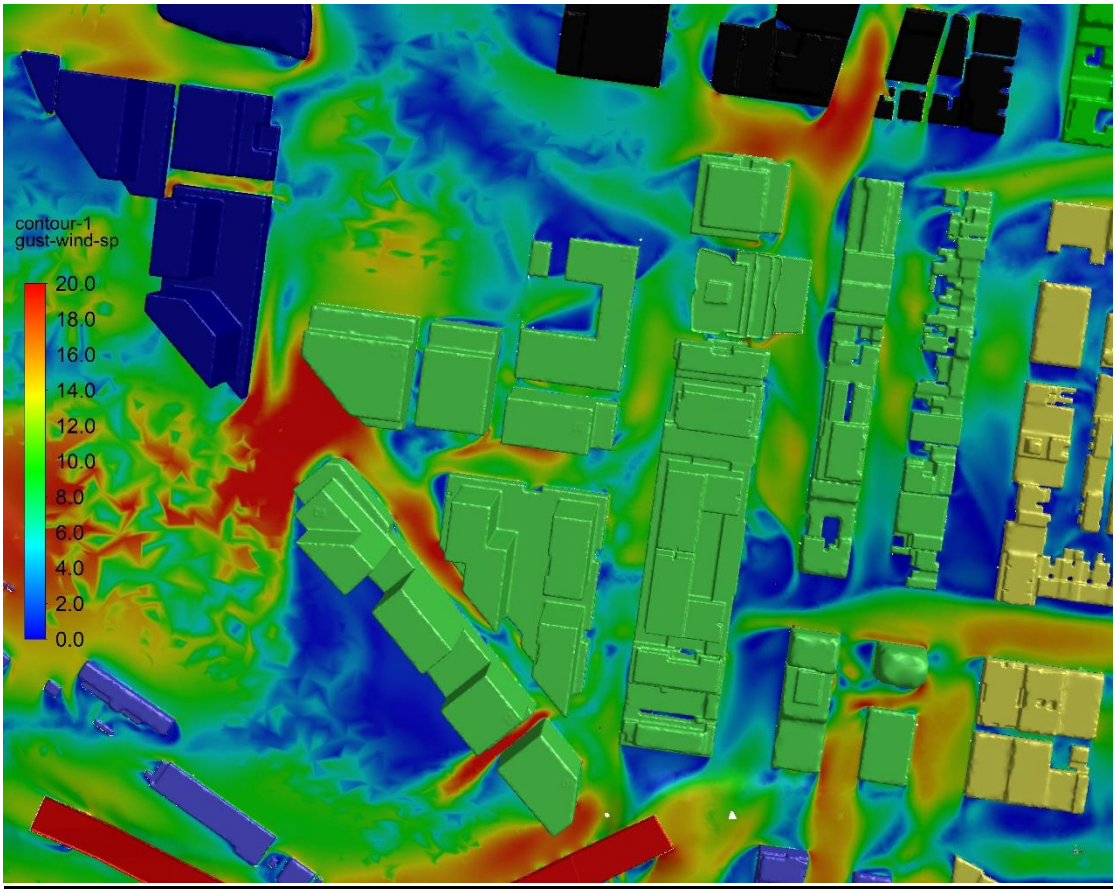



contour-1
gust-wind-sp
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0


vector-1
gust-wind-sp
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0


contour-1
18.0
16.0
14.0
10.0
8.0
6.0
4.0
2.0
0.0


18.0
2.0
6.0
4.0
2.0
0.0


contour-1
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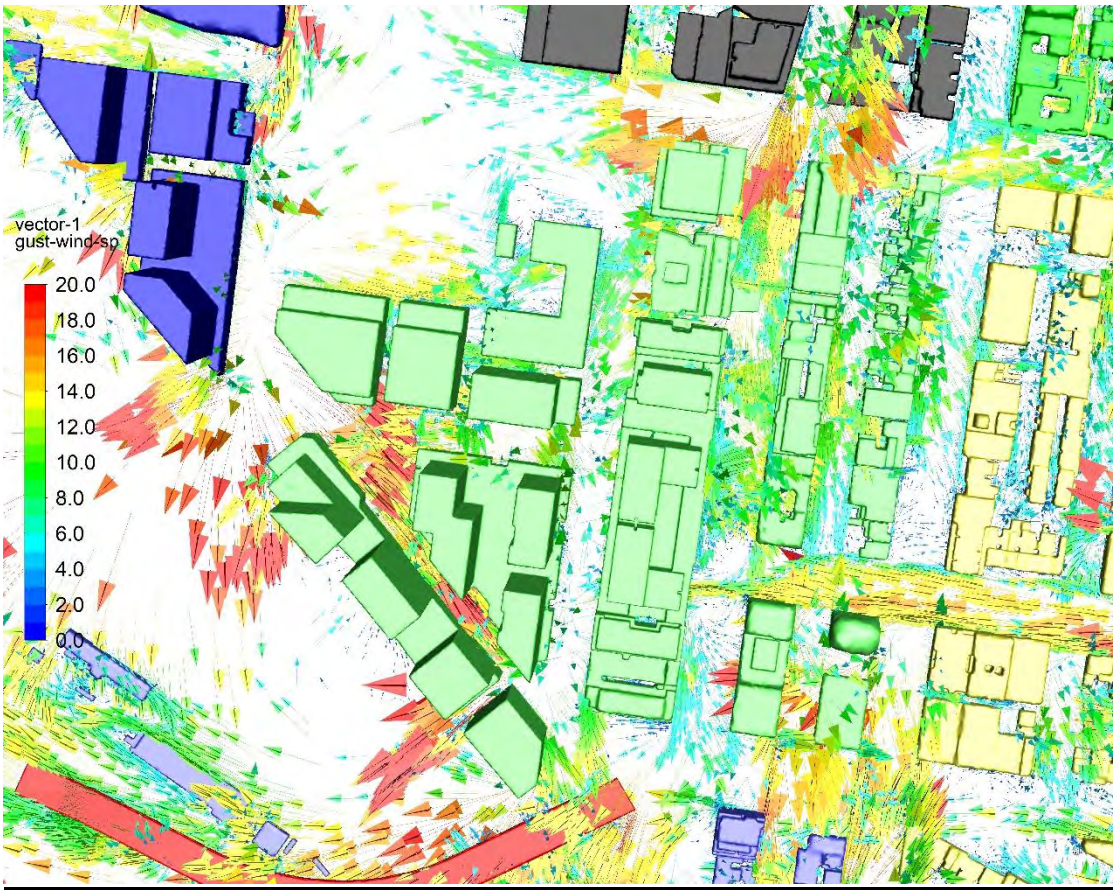
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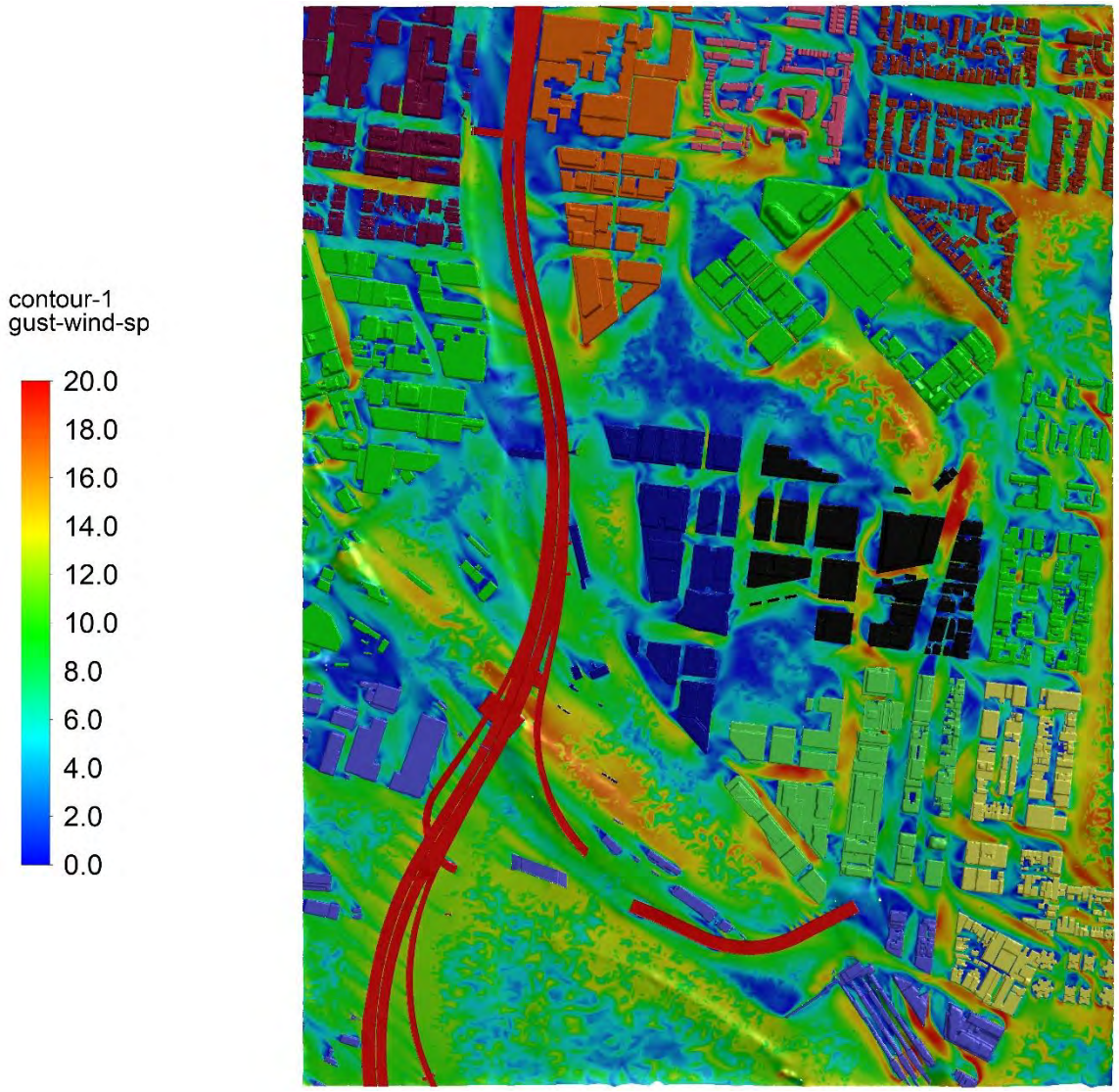

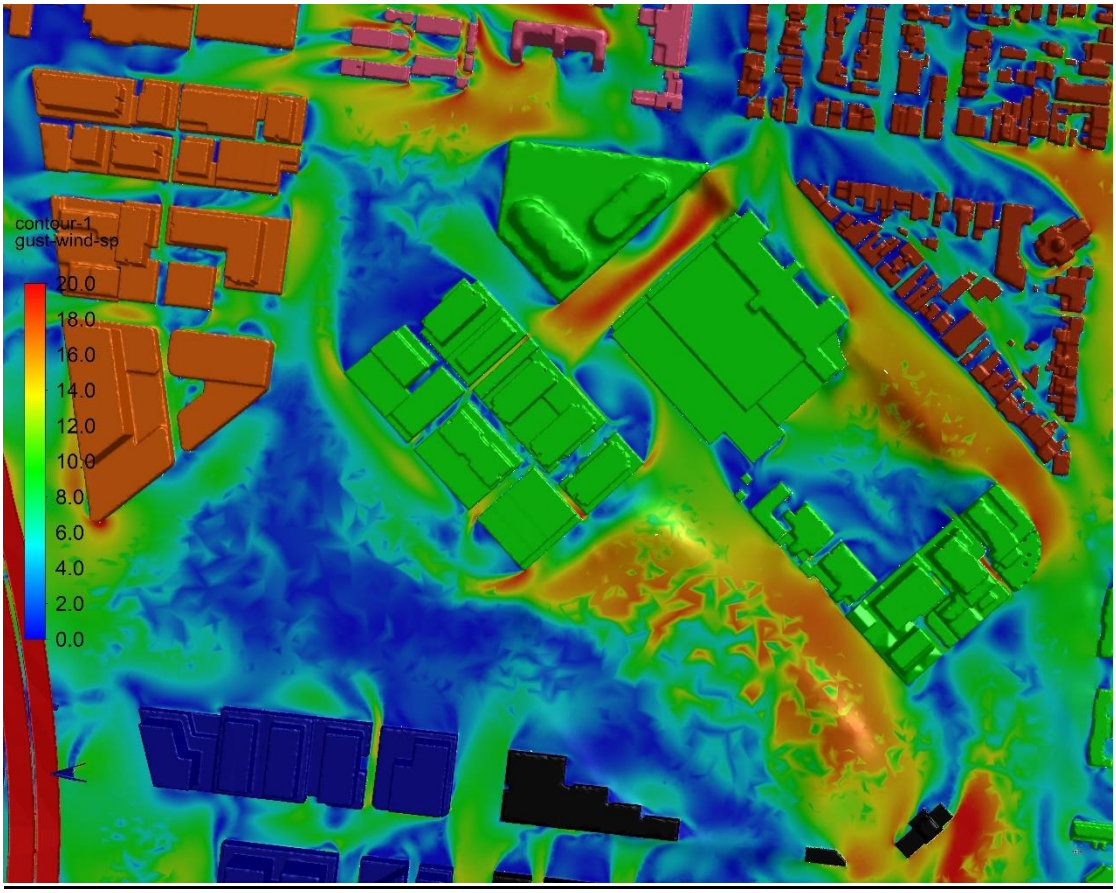
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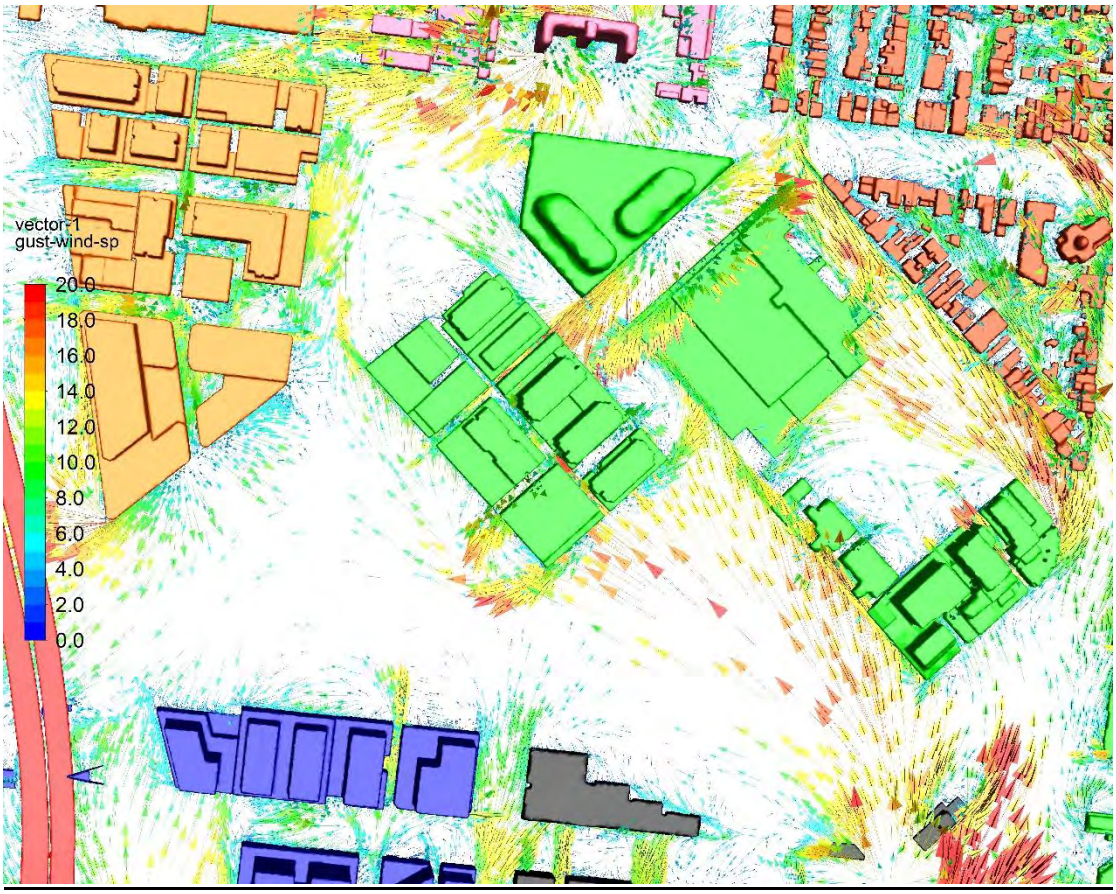
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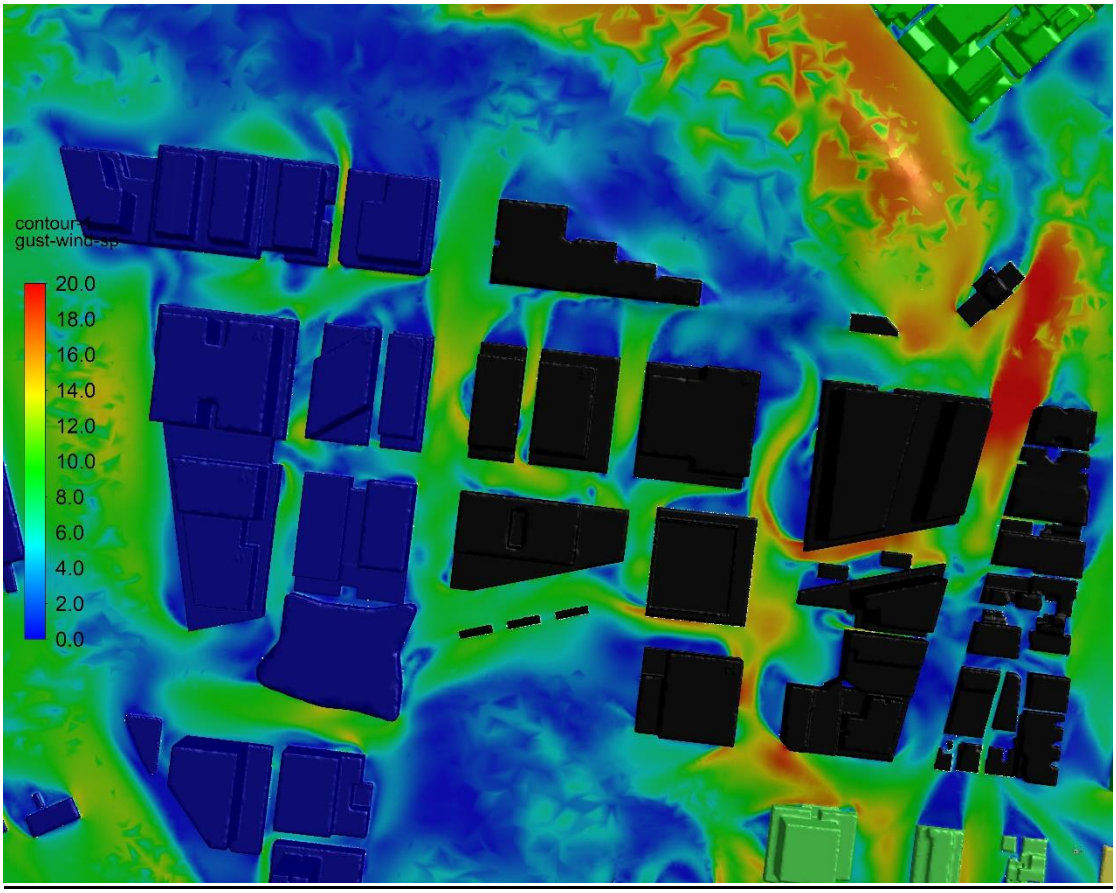
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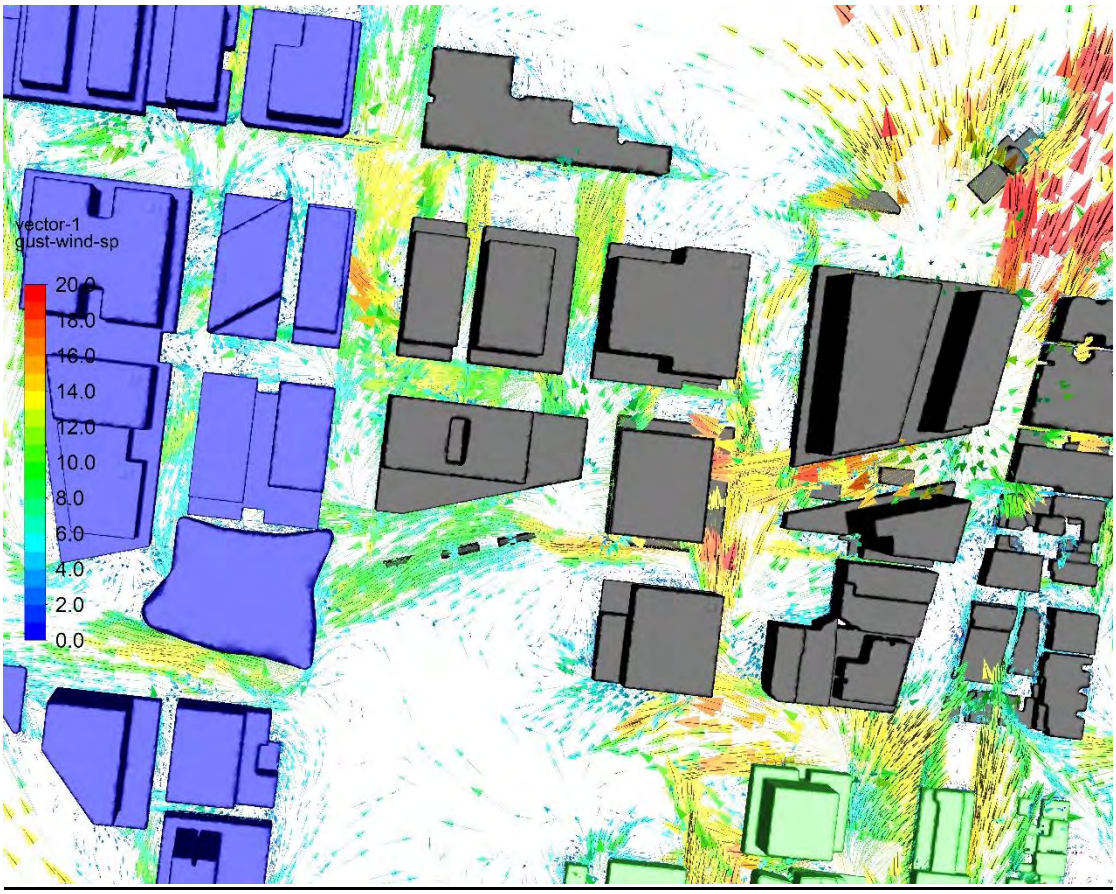
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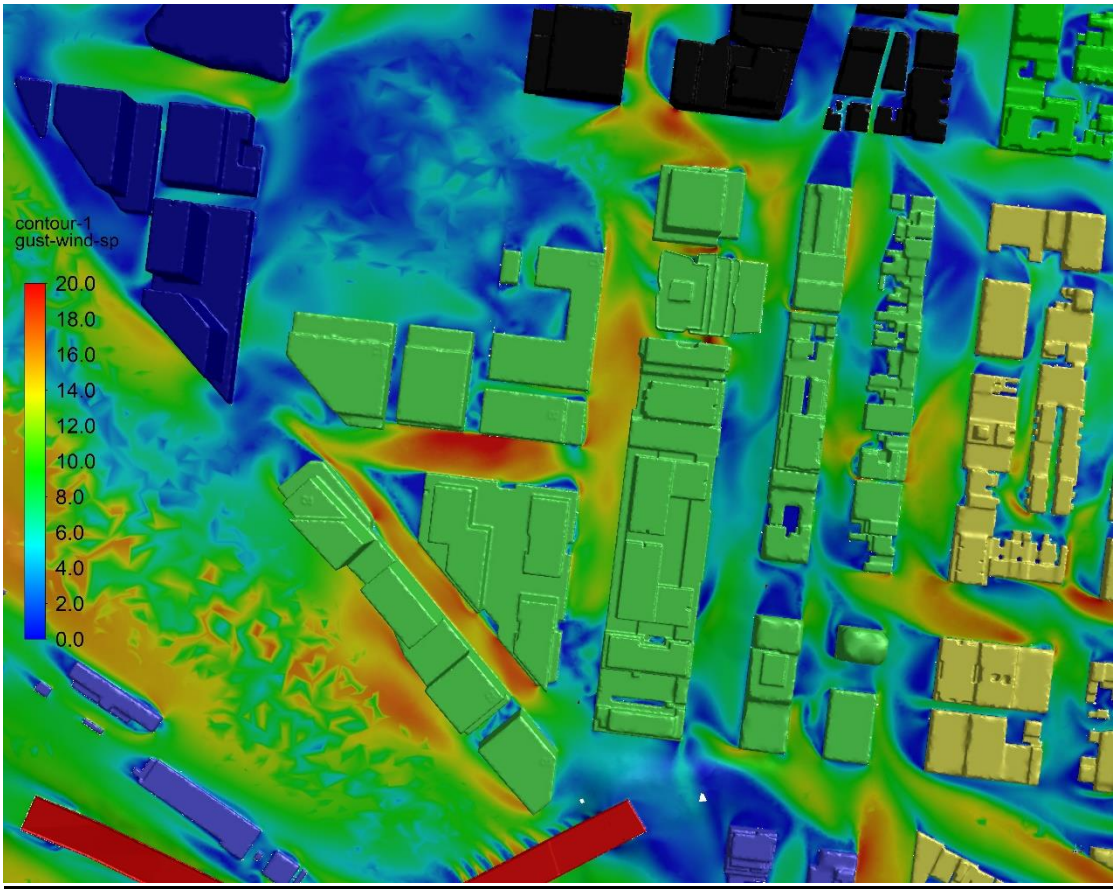
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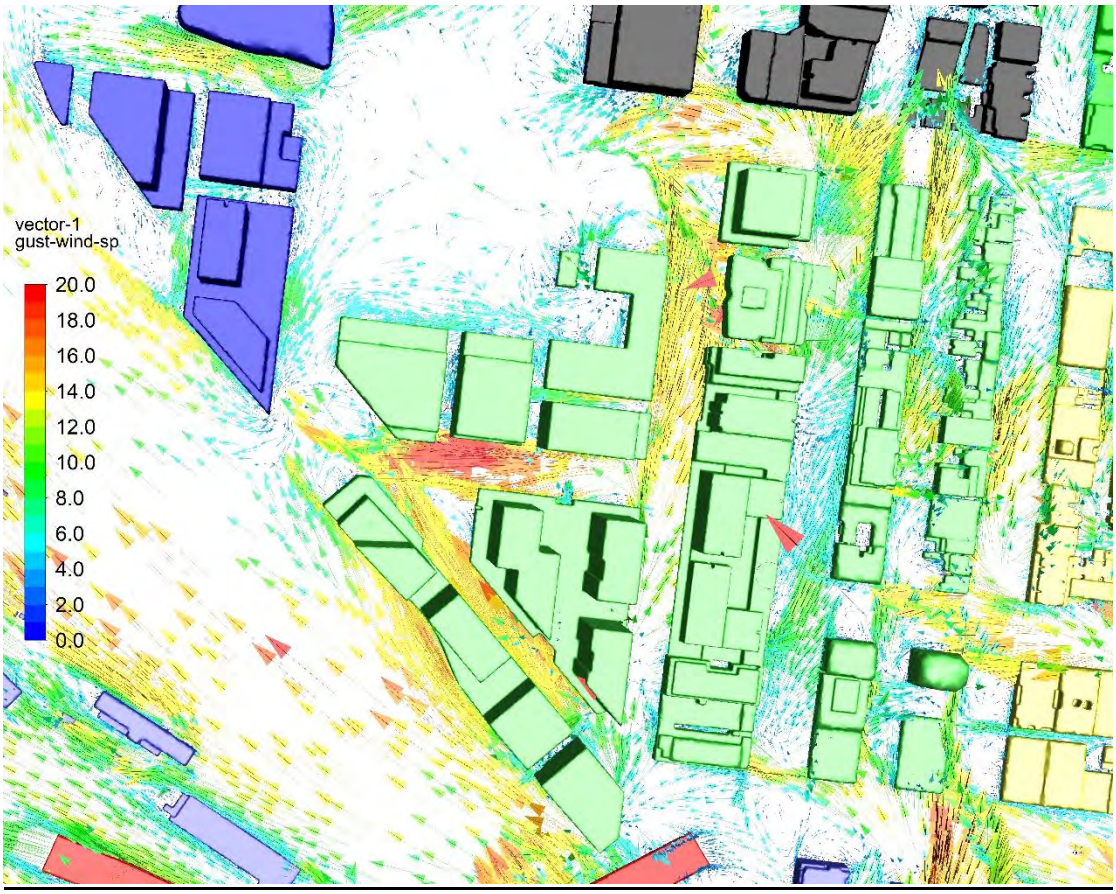
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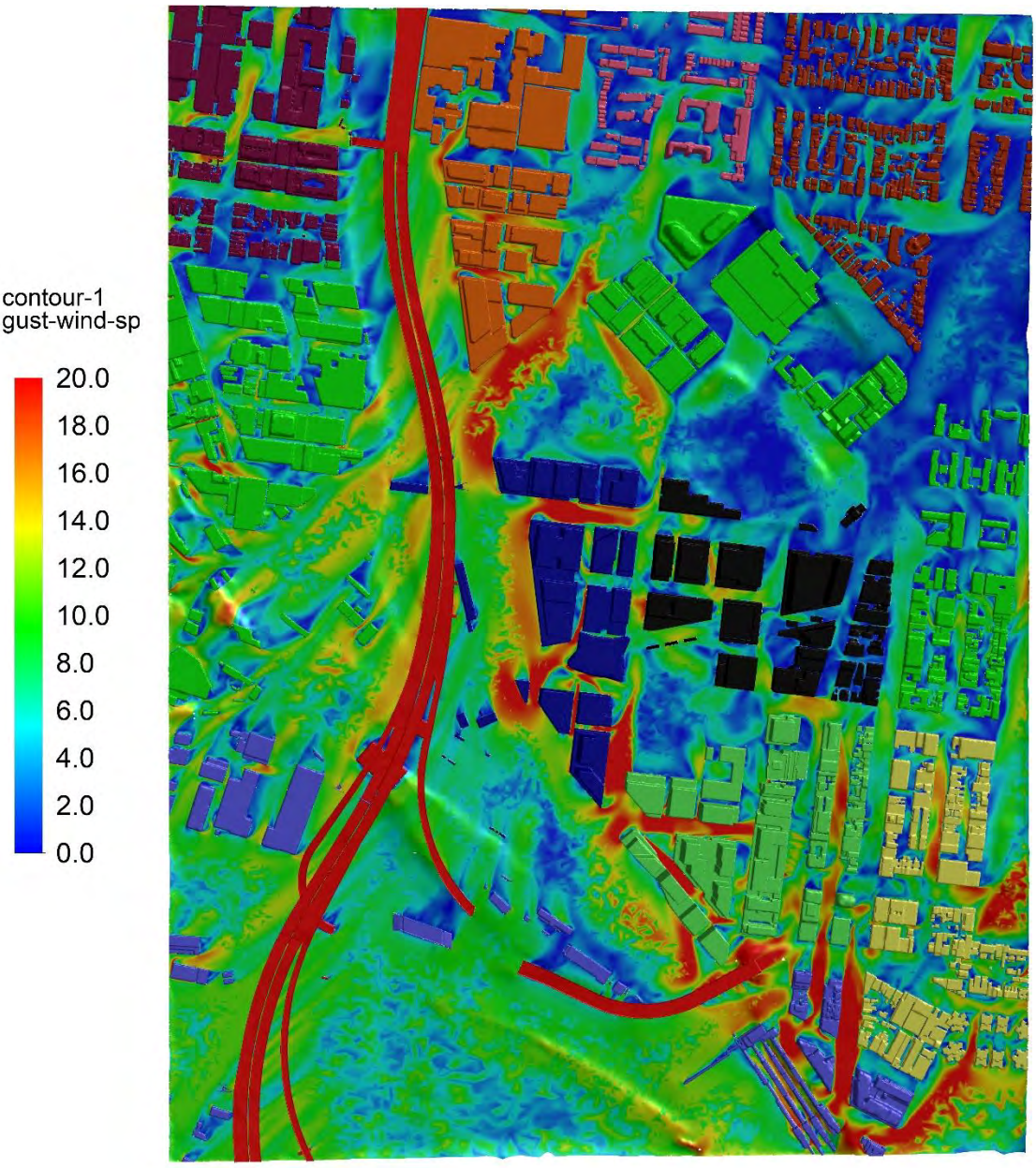

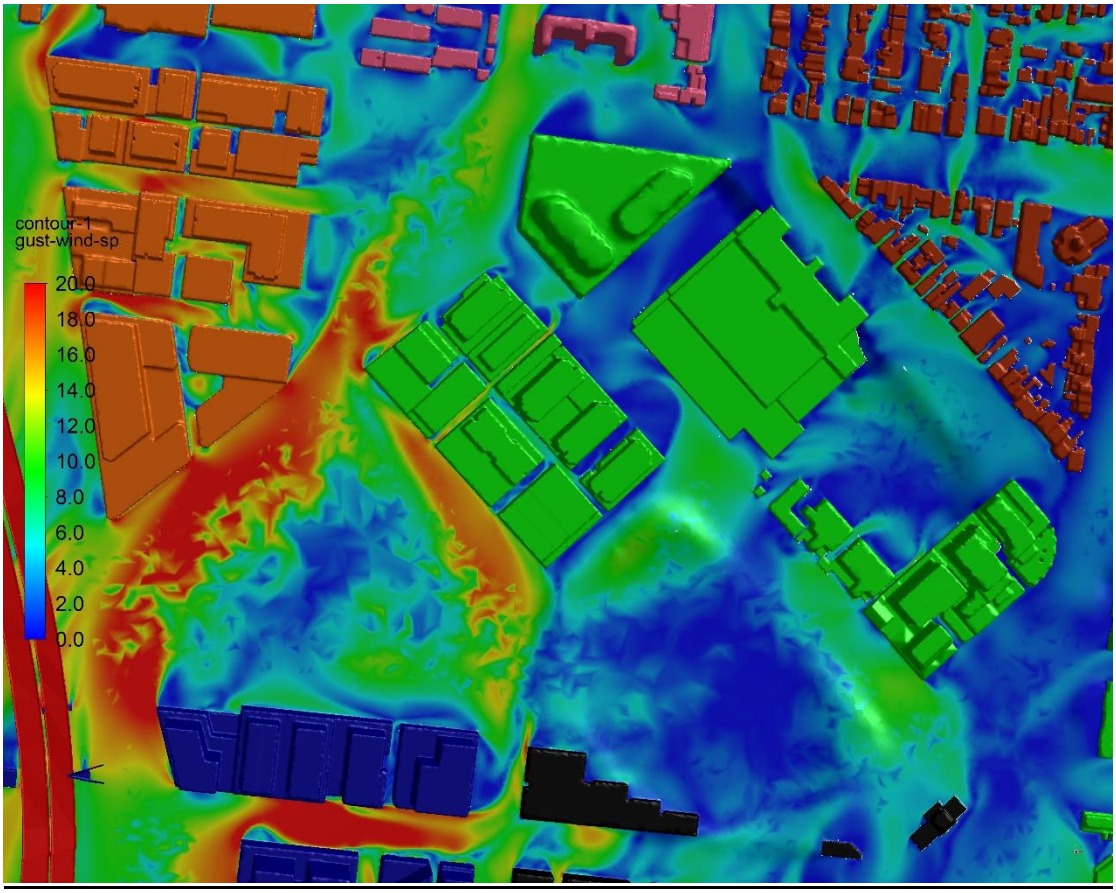
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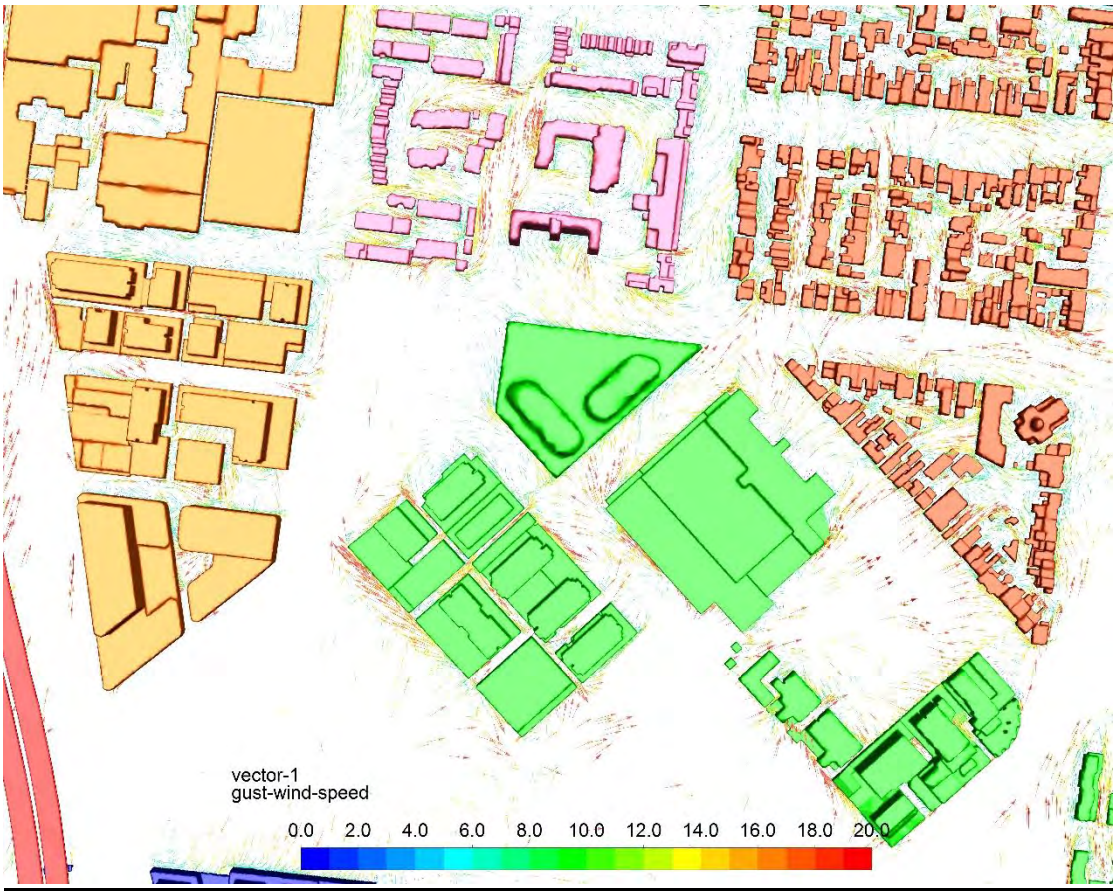
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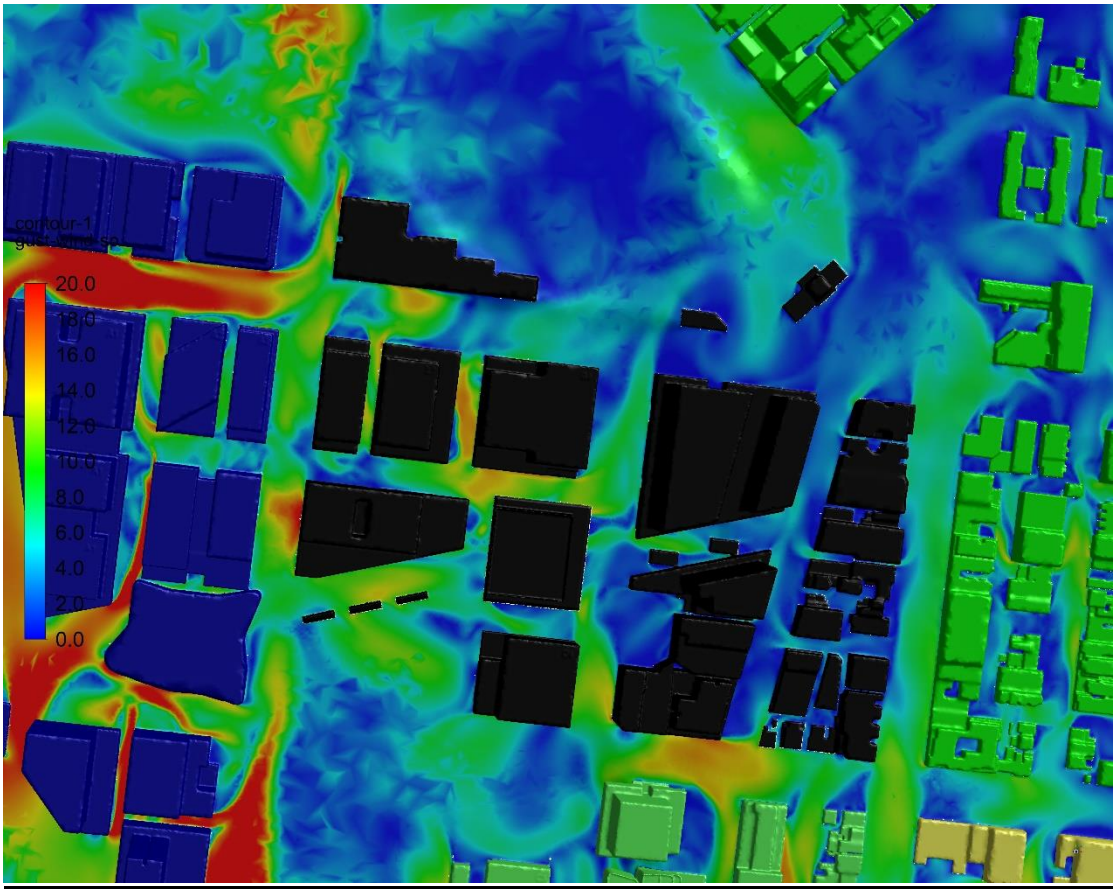
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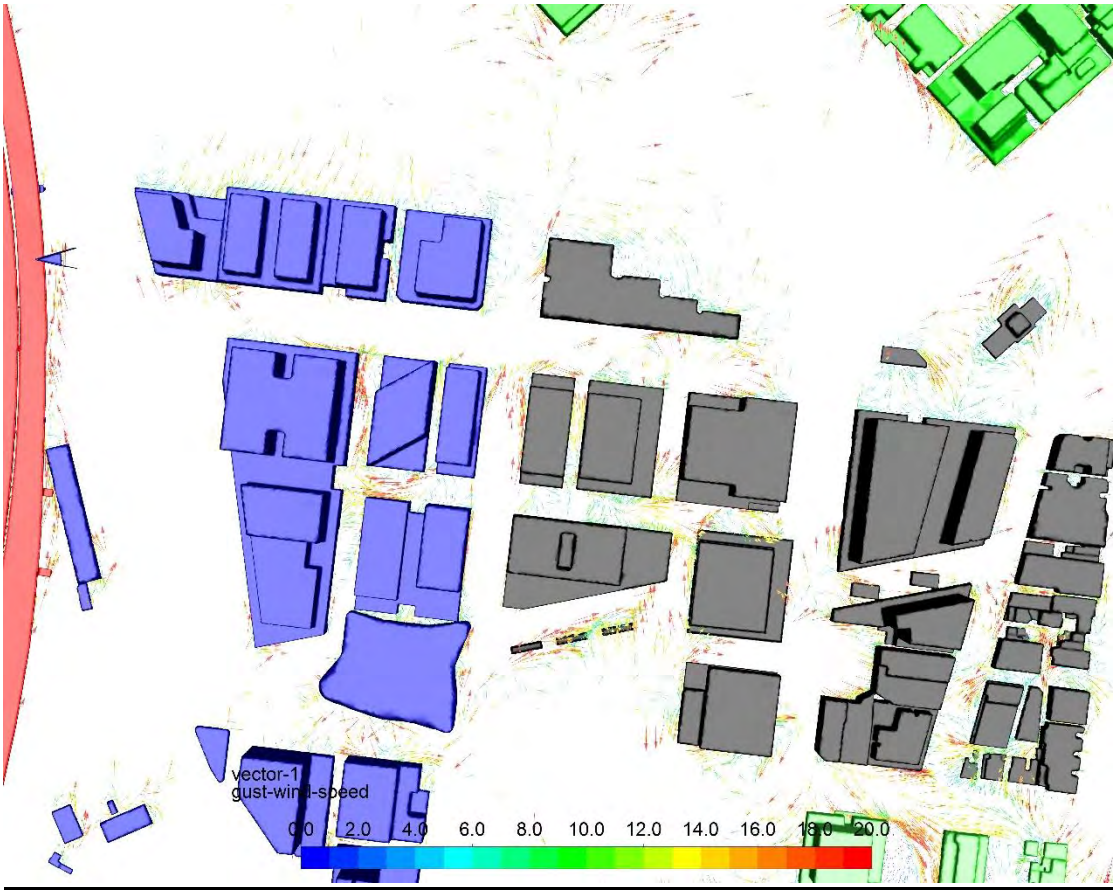
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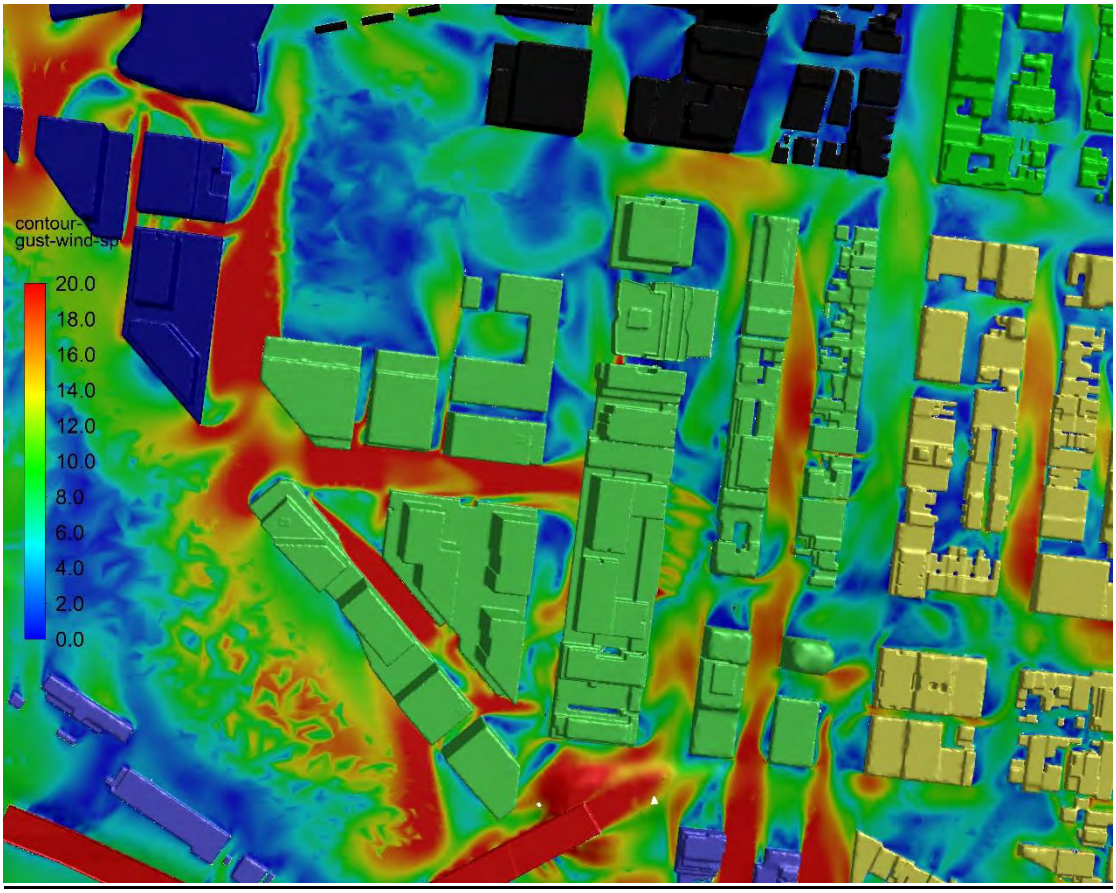
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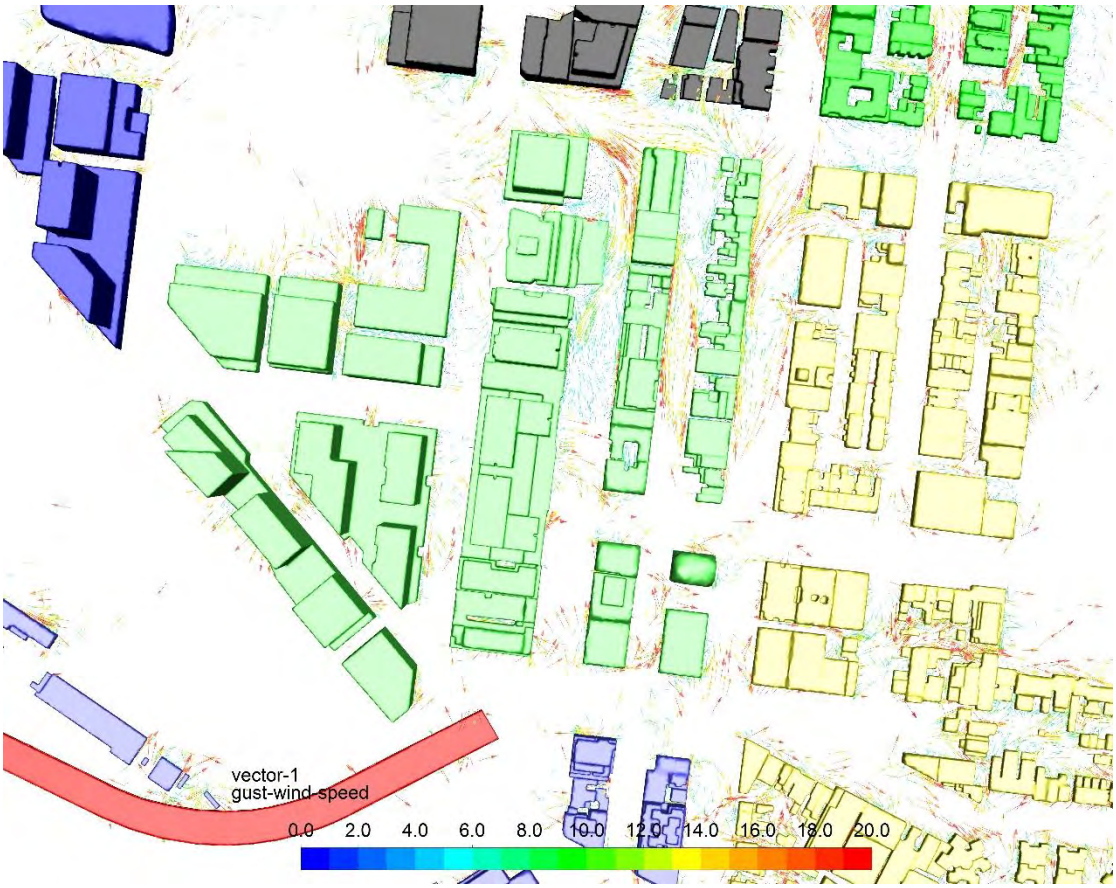
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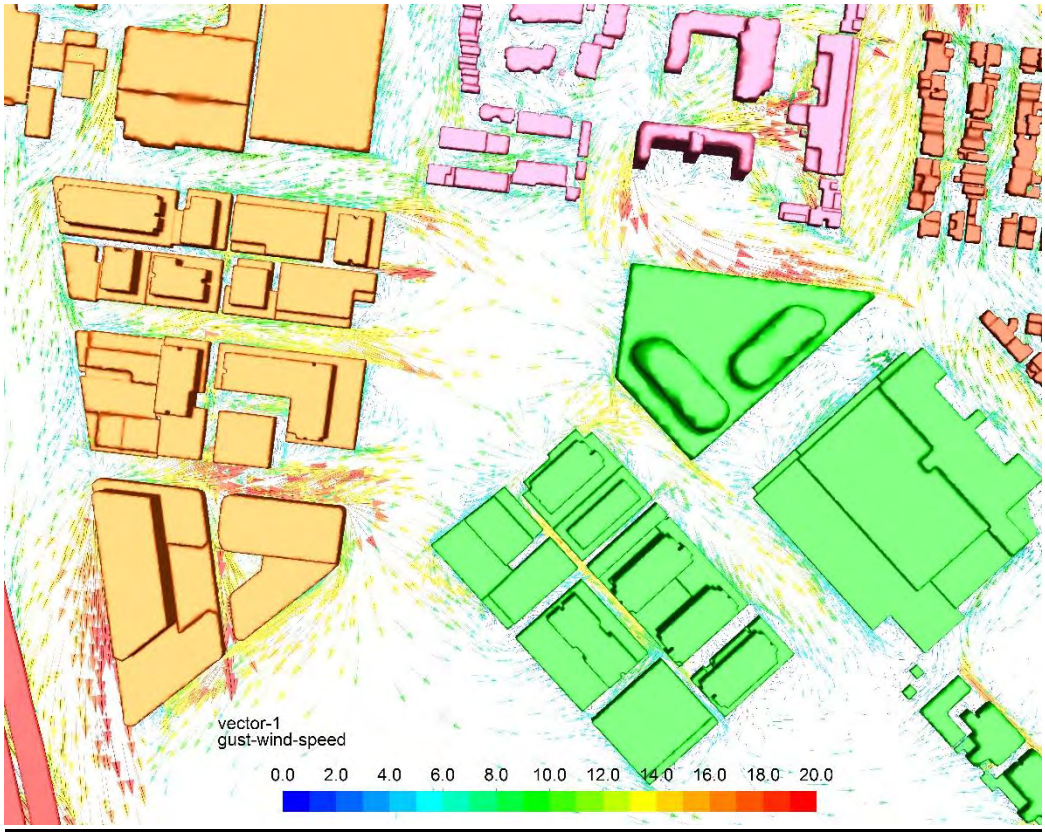
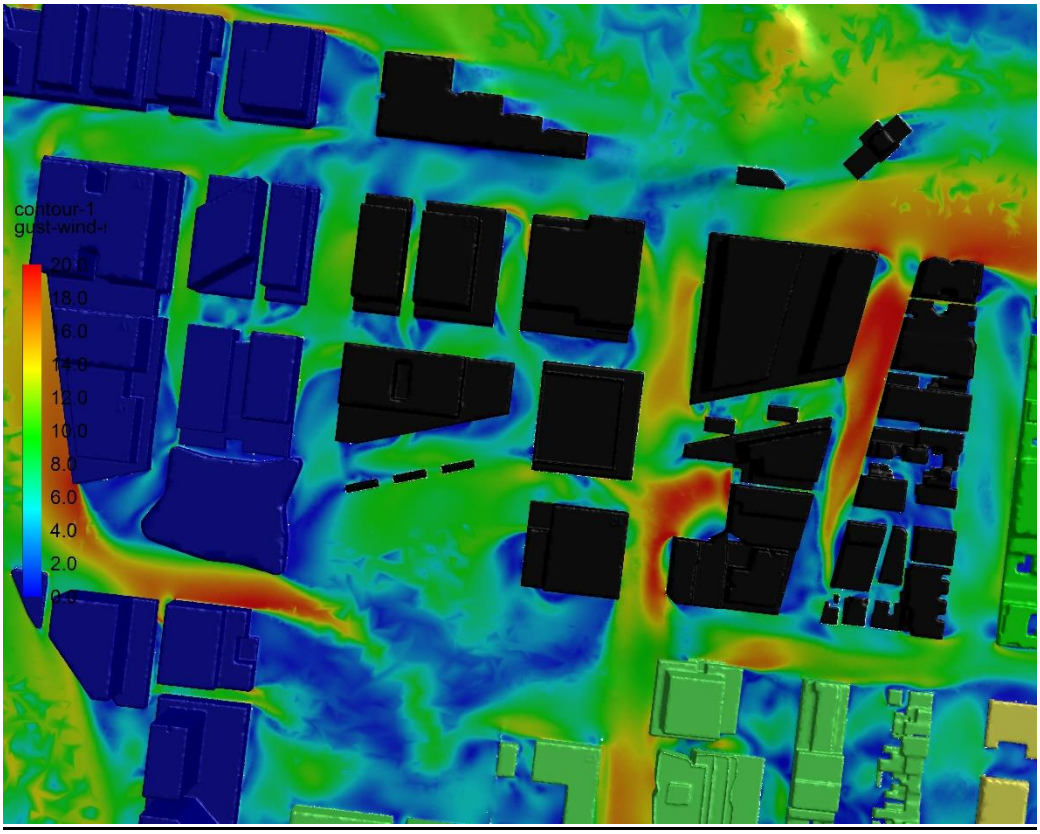
North West:

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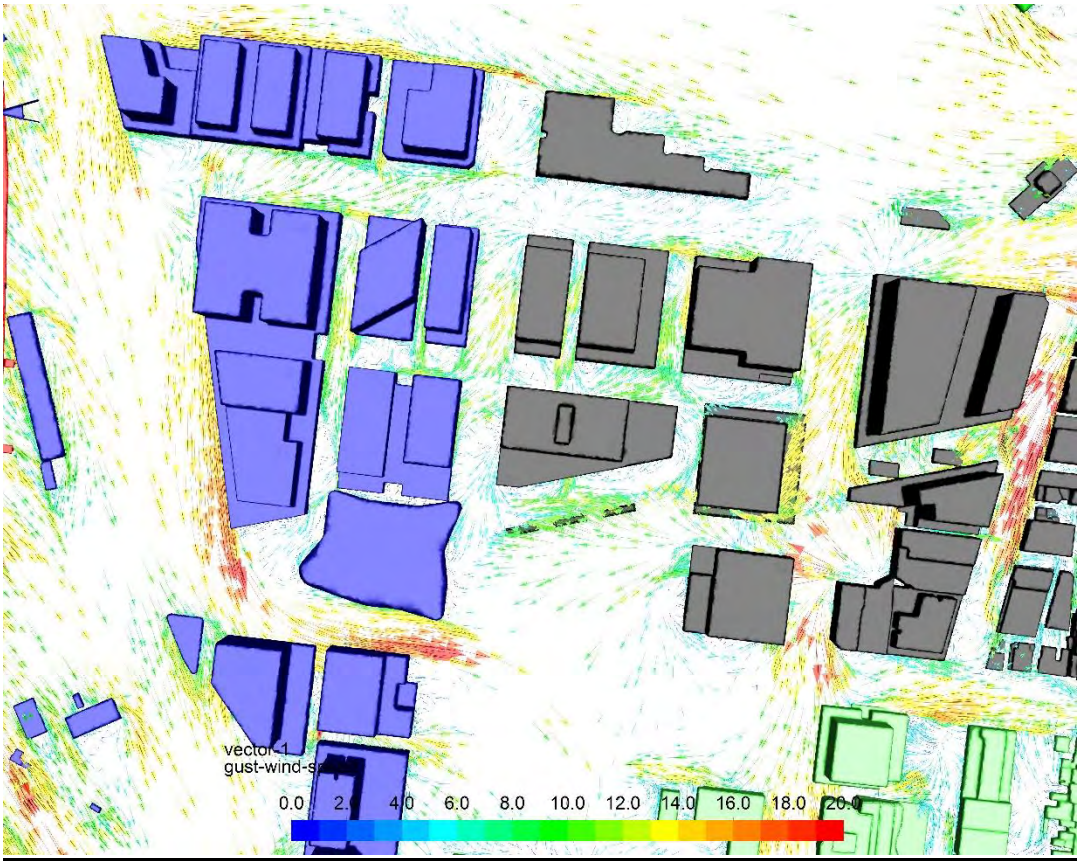
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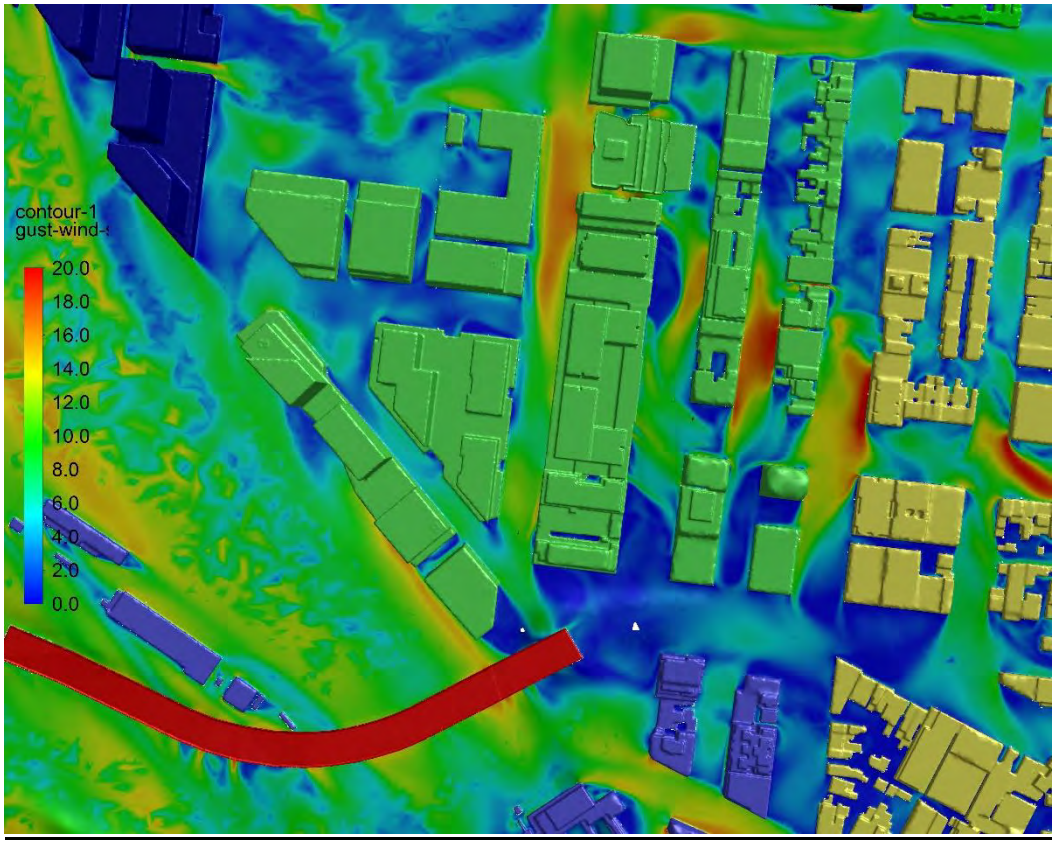
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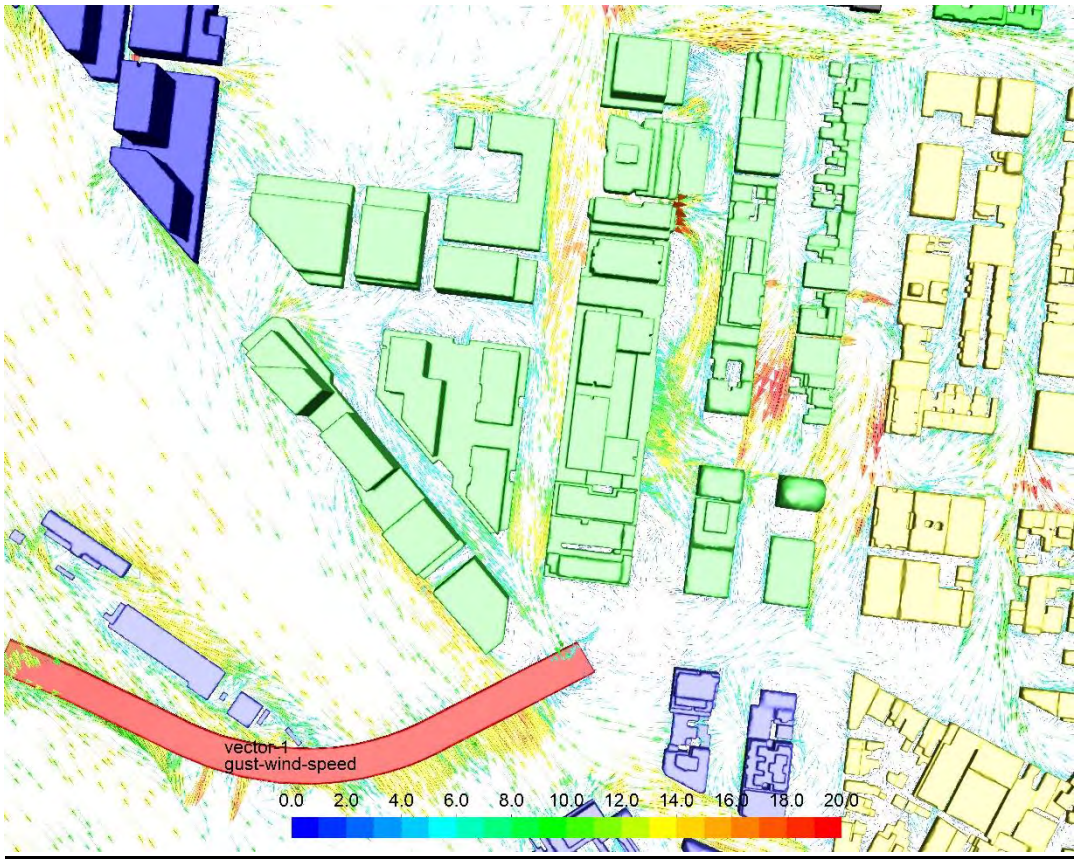
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10.0
12.0
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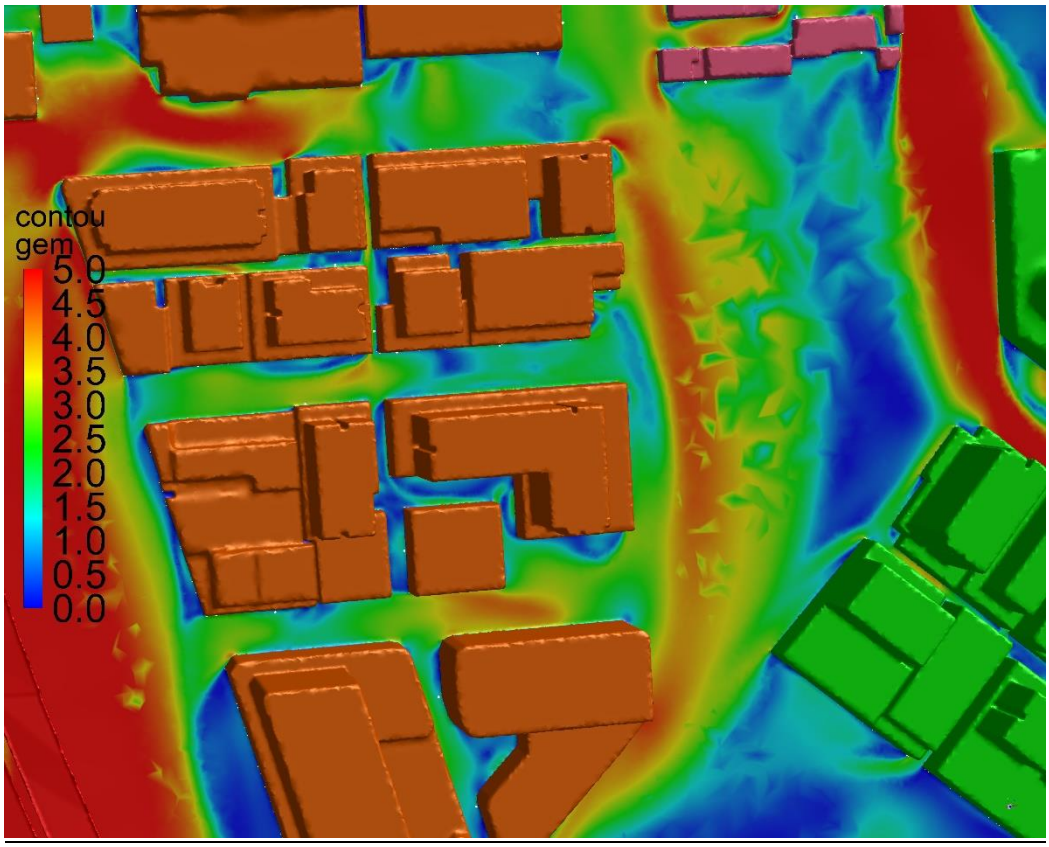
APPENDIX C

Contour Plots of the Gust Equivalent Mean wind speed for N, NE, E, SE, S, SW, W and NW directions

North: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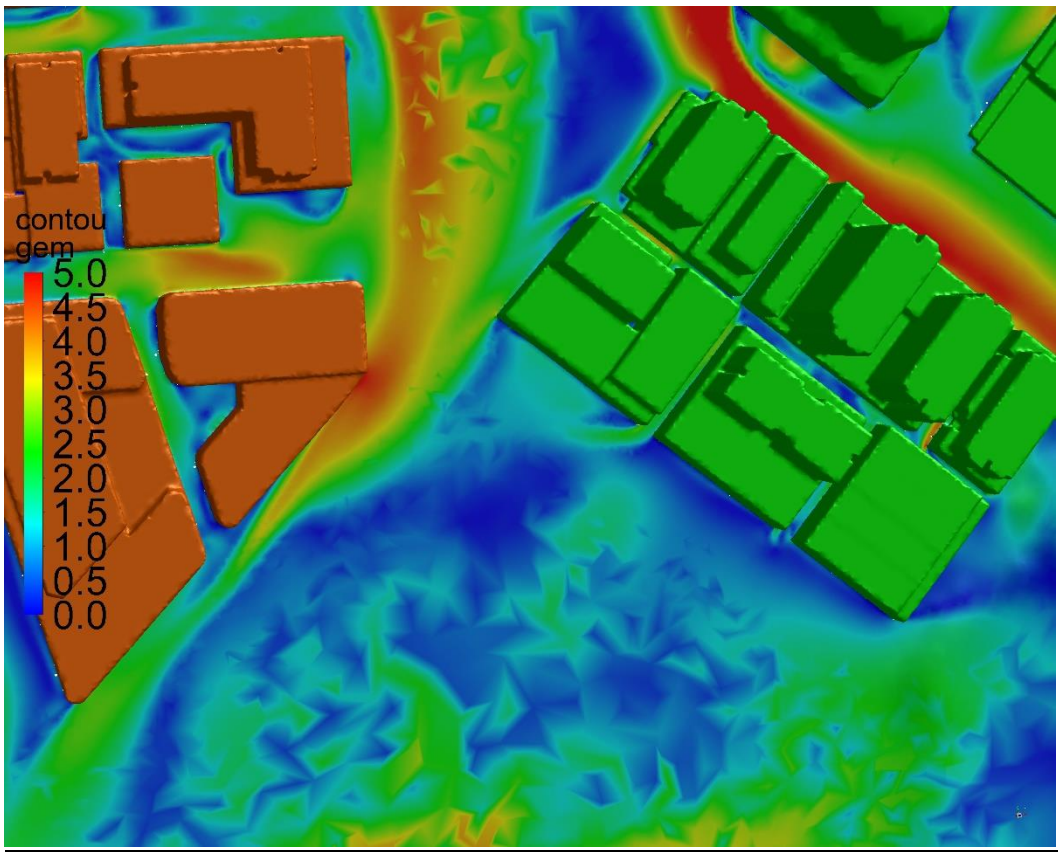
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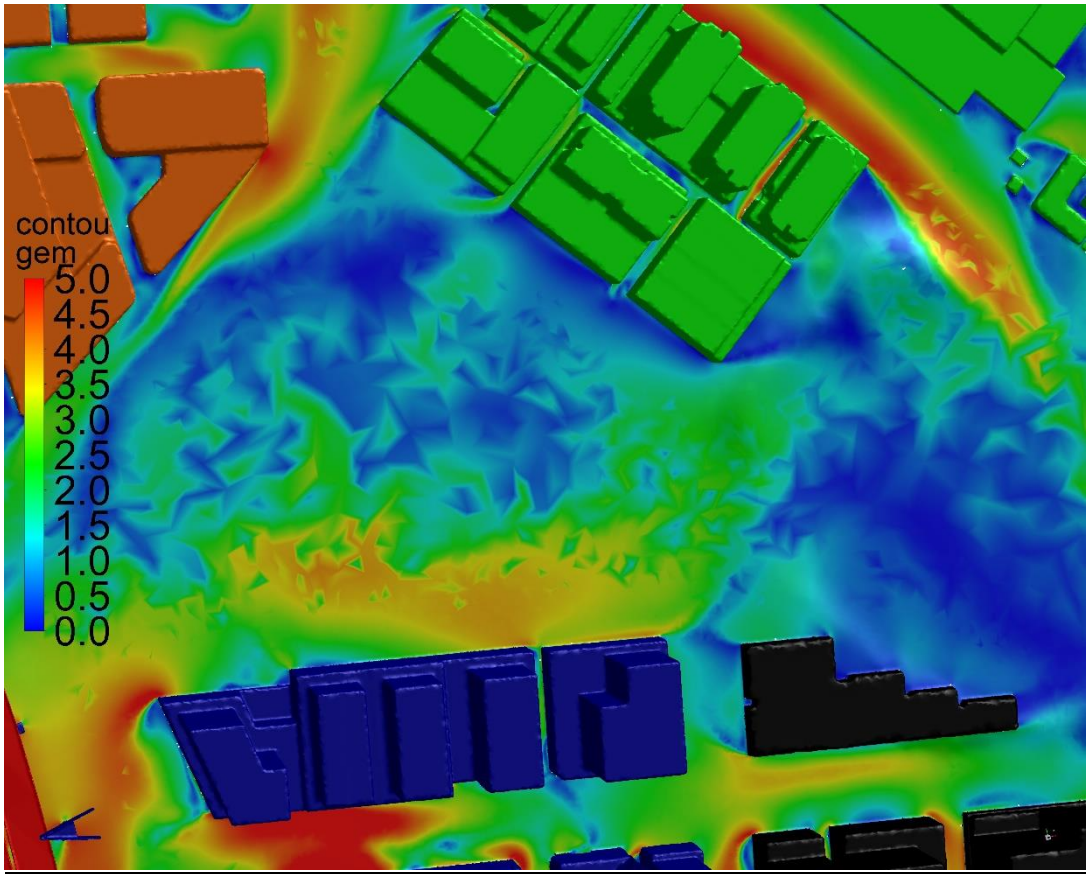
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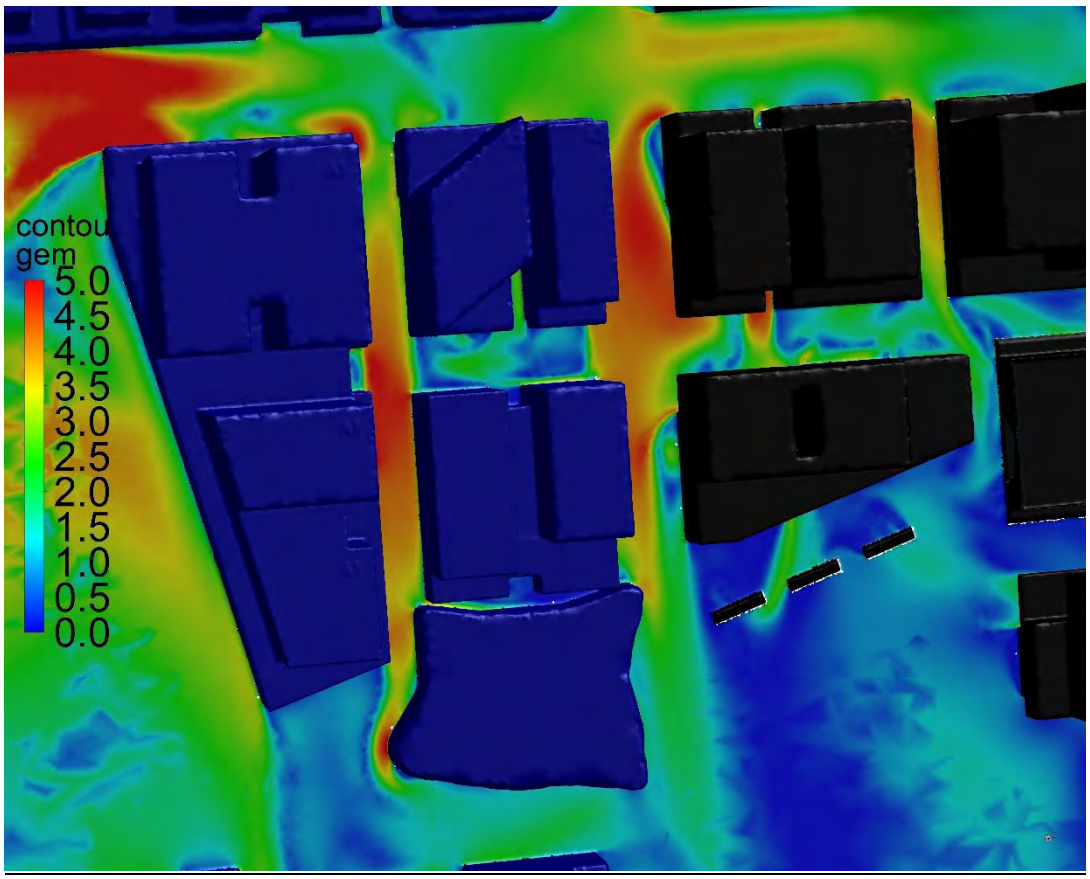
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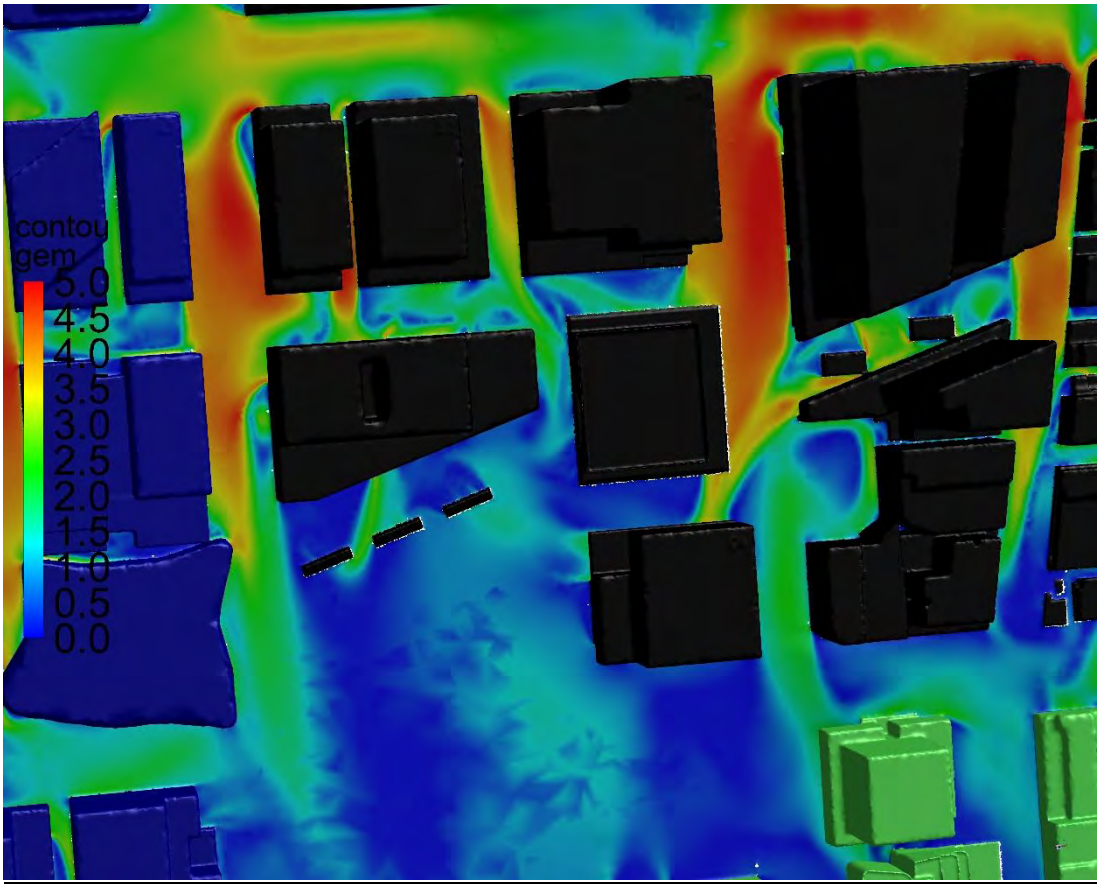
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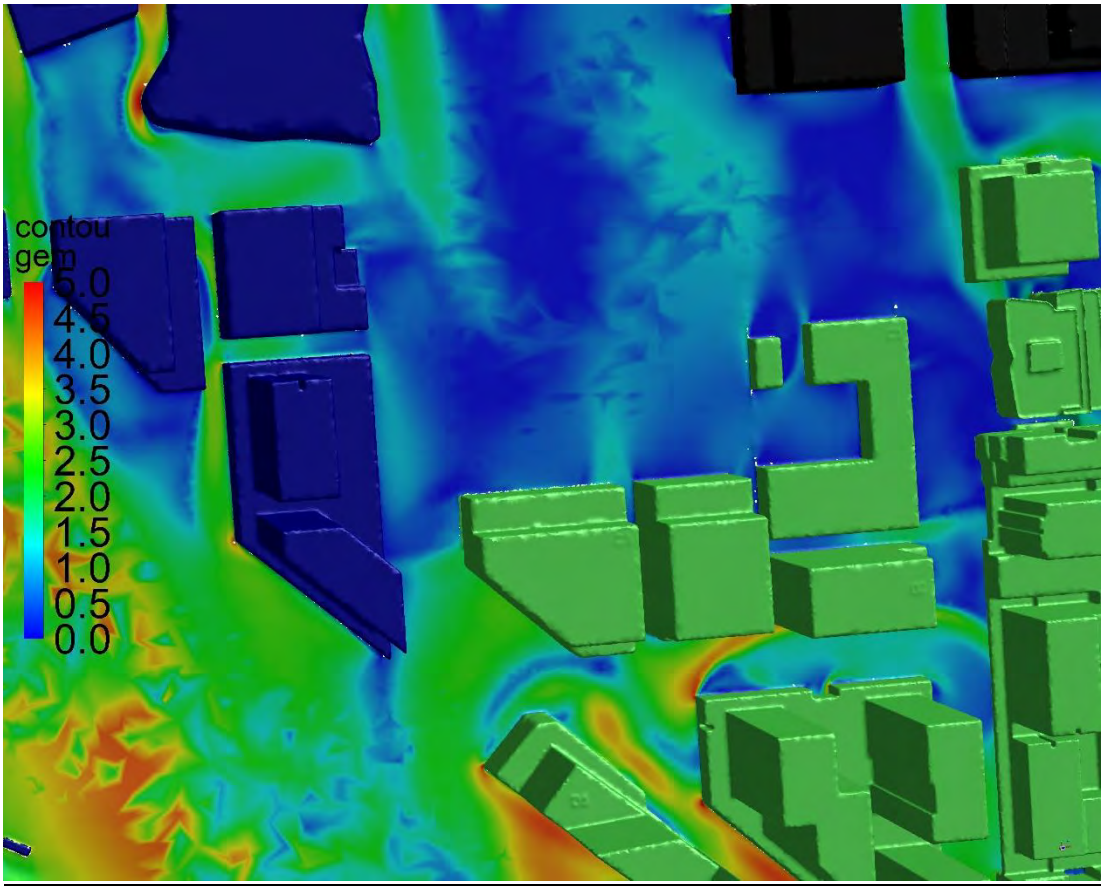
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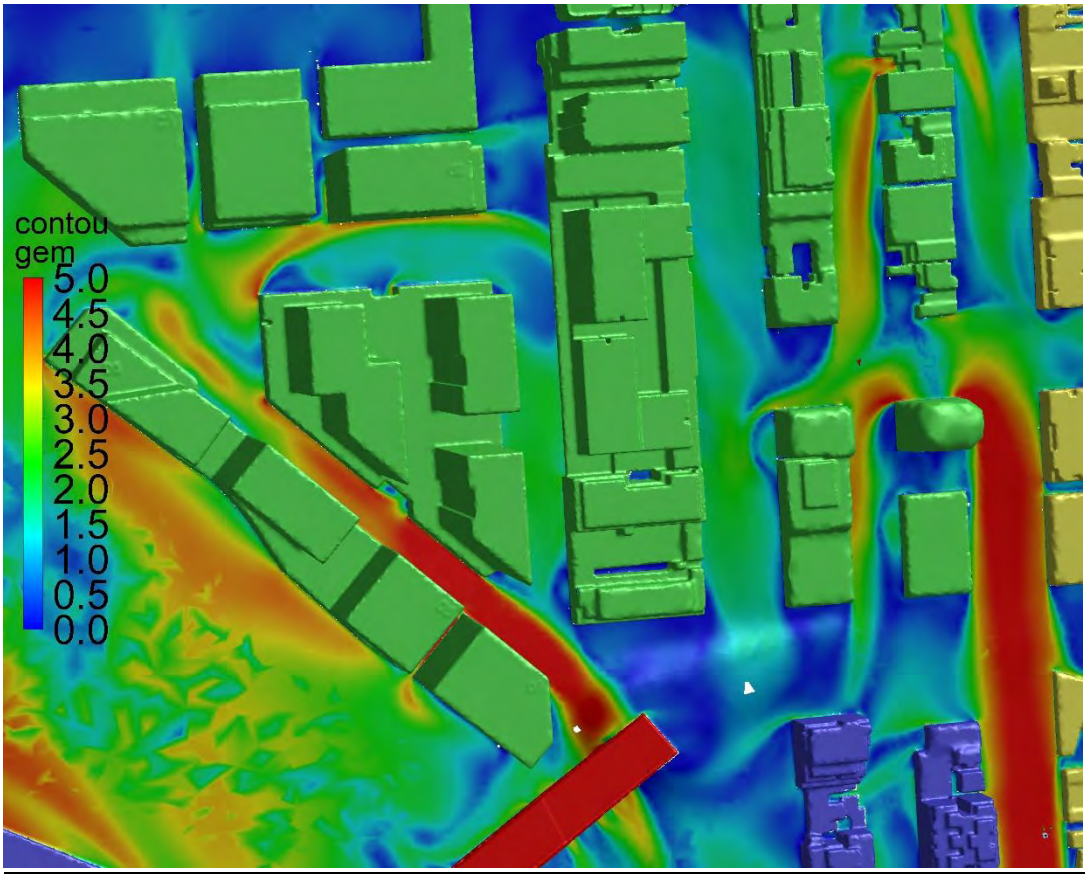
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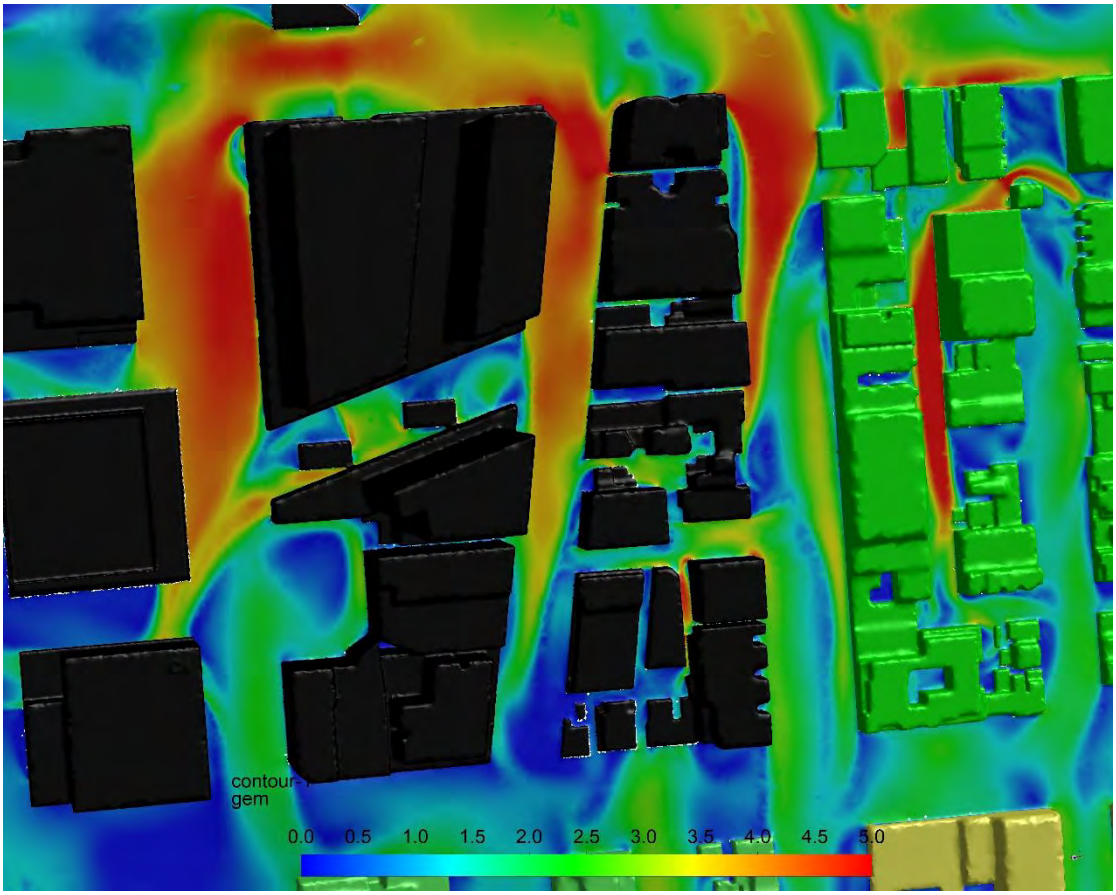
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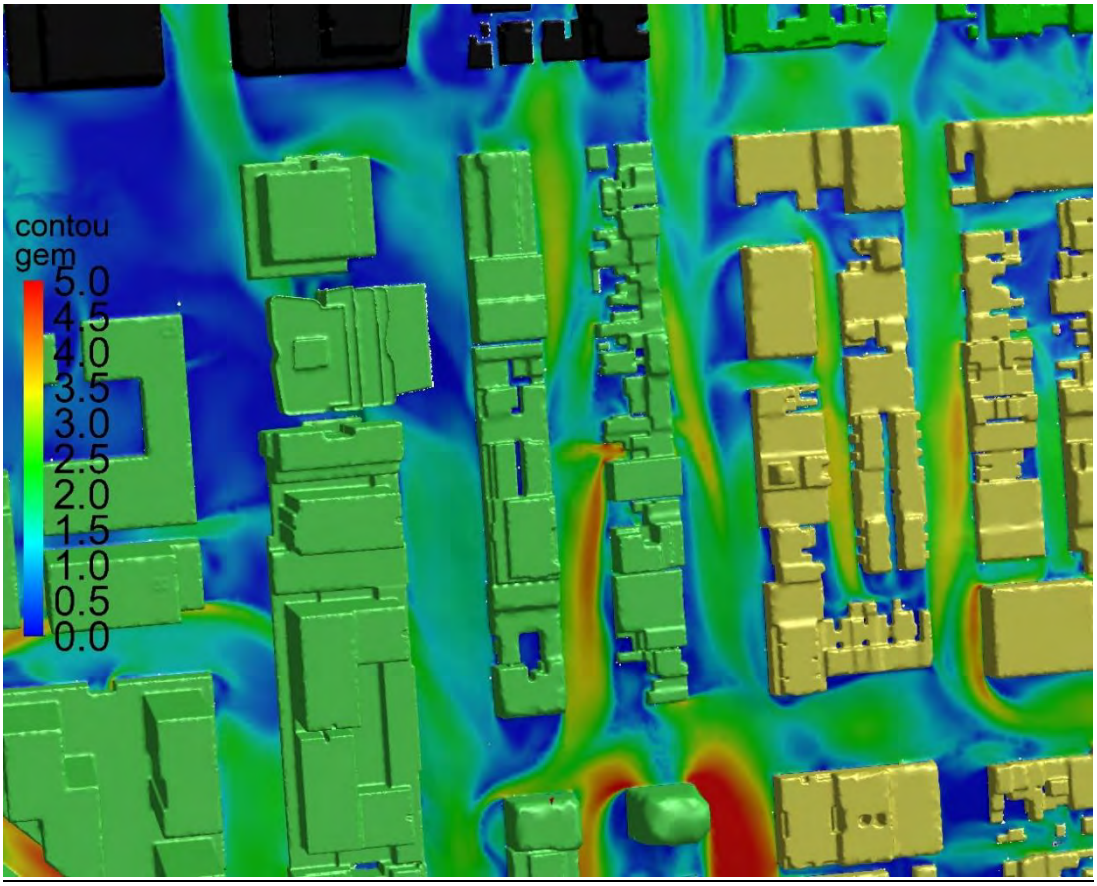
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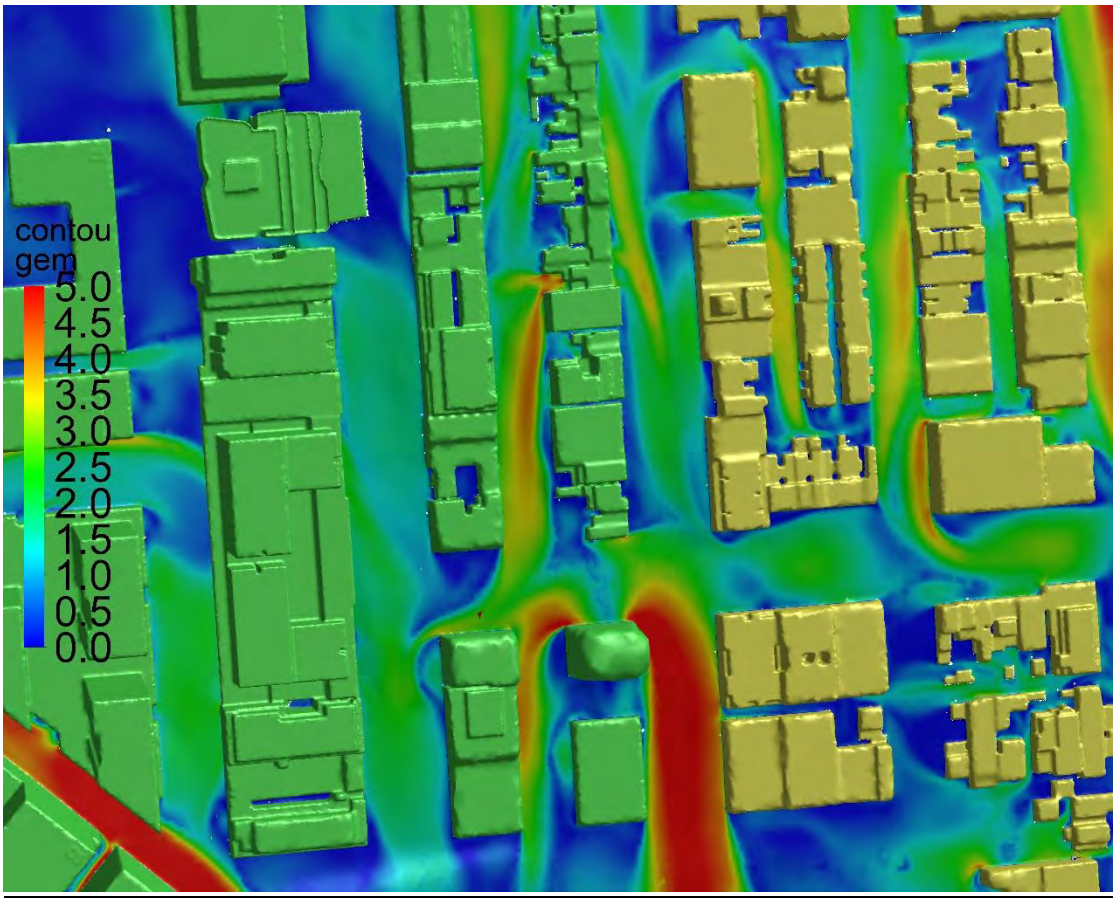
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1.0
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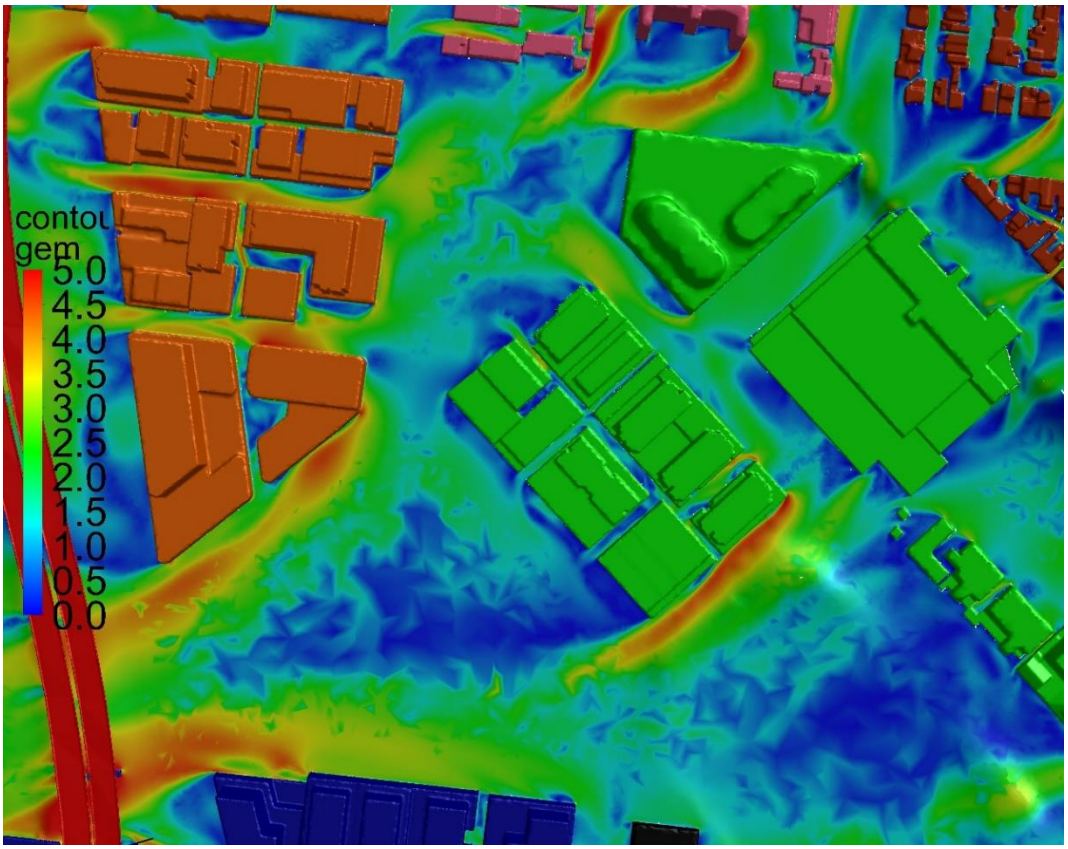
North East: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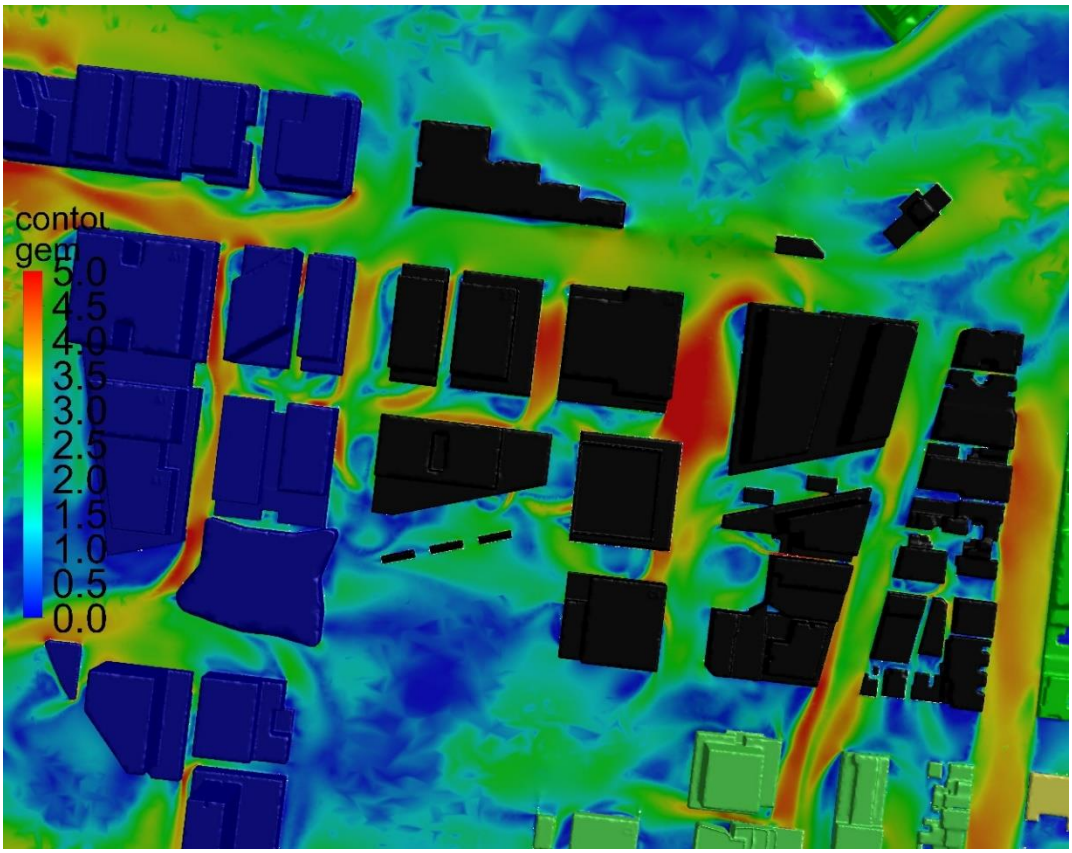
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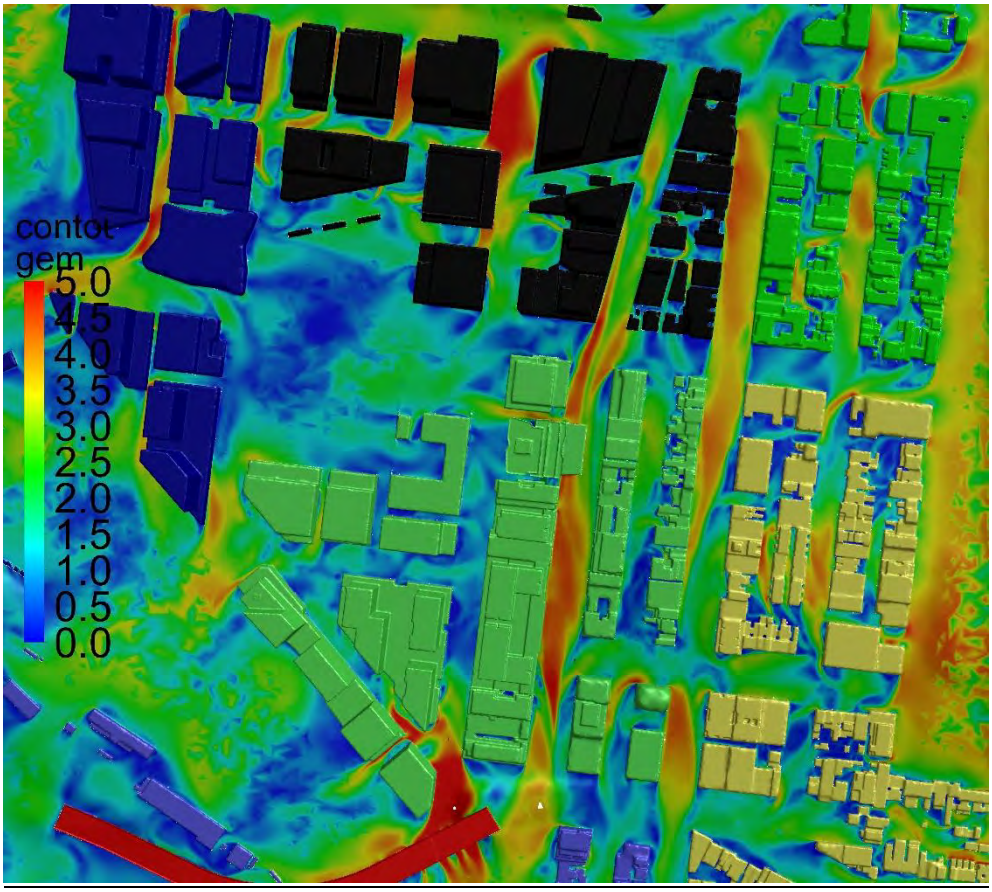
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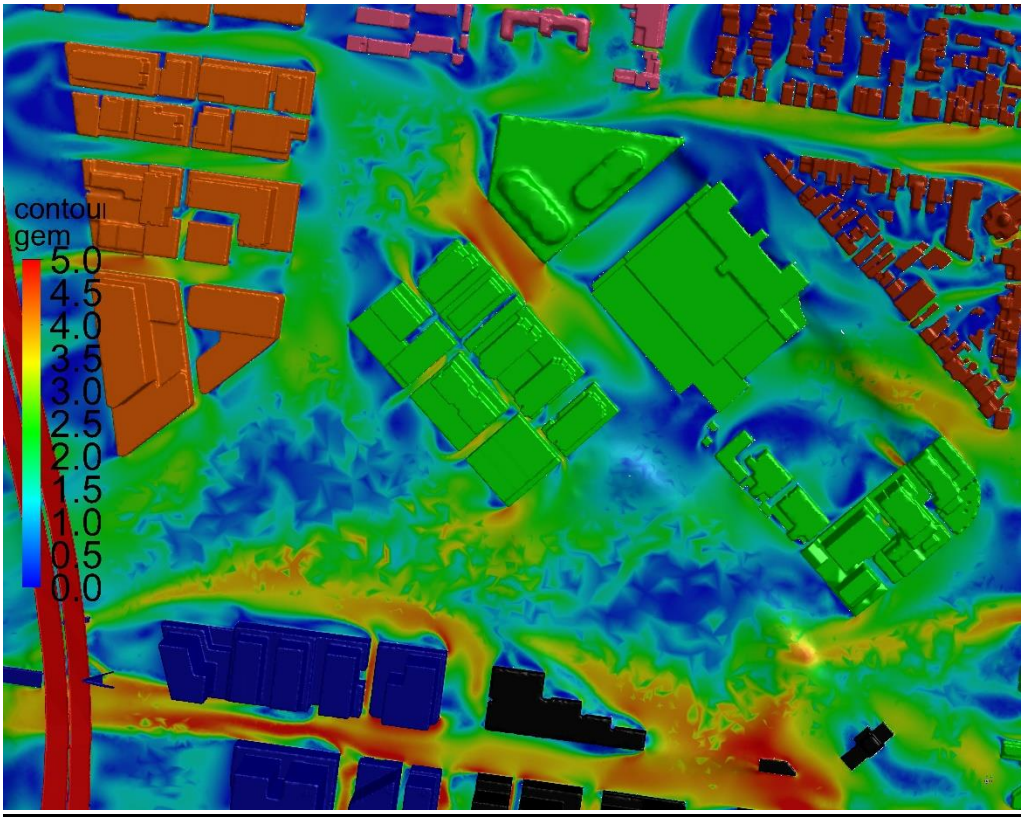
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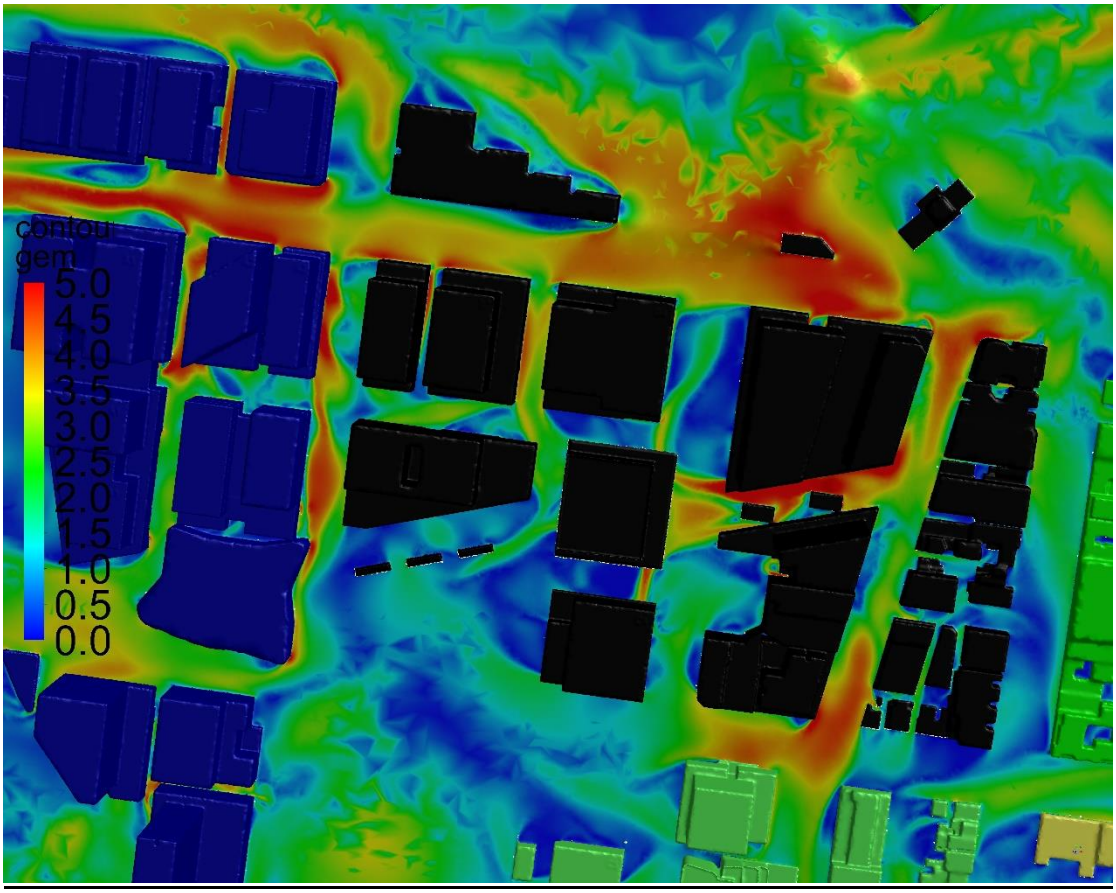
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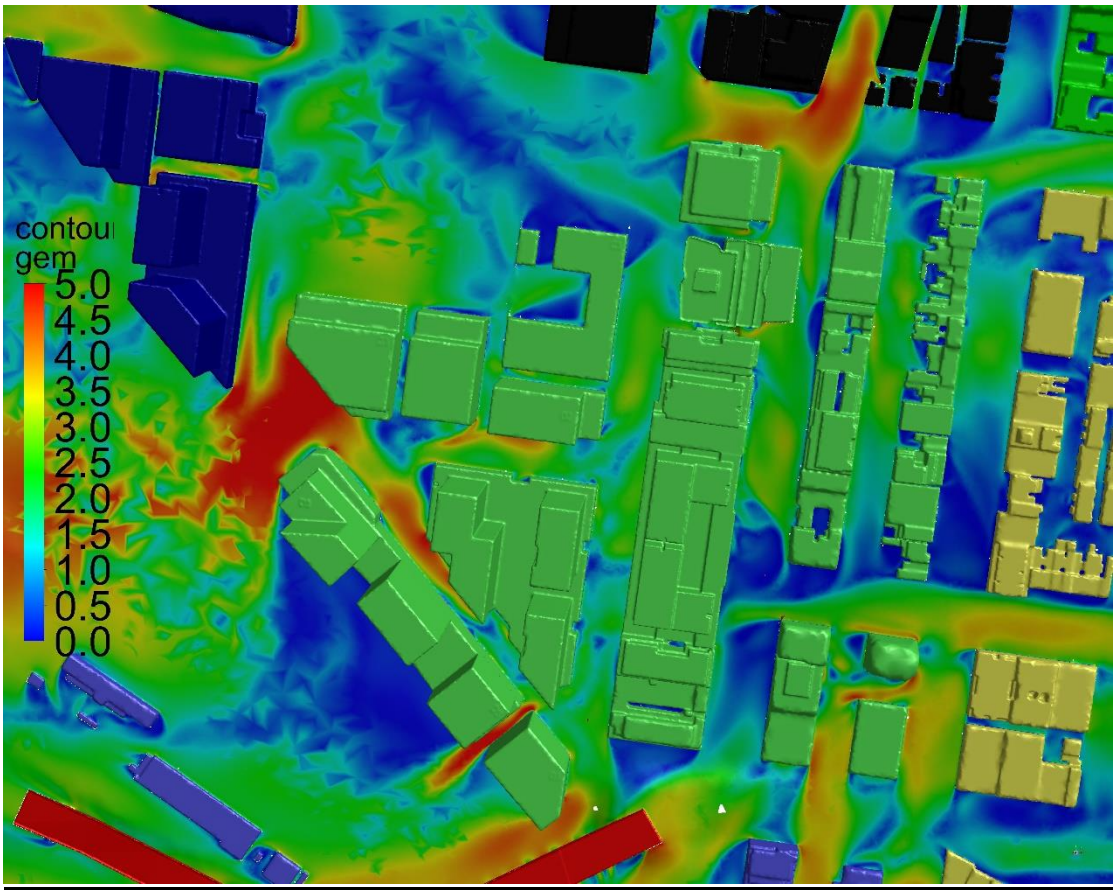
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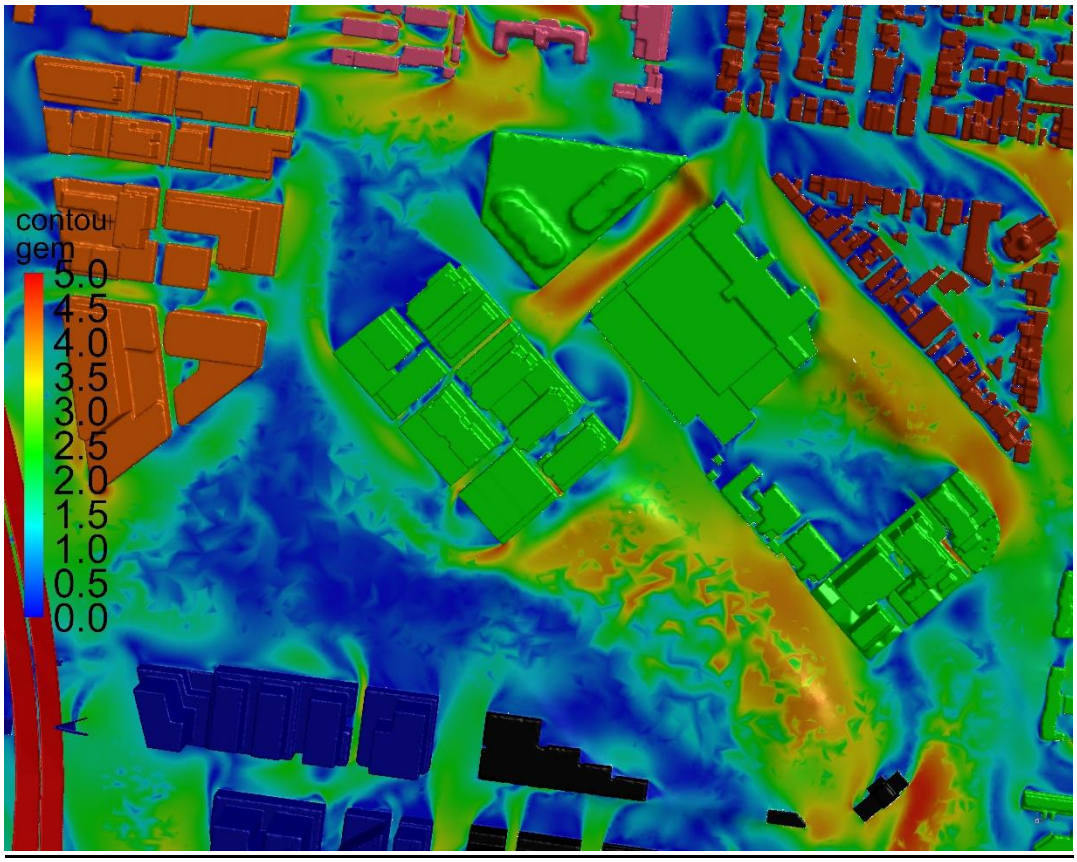
South East: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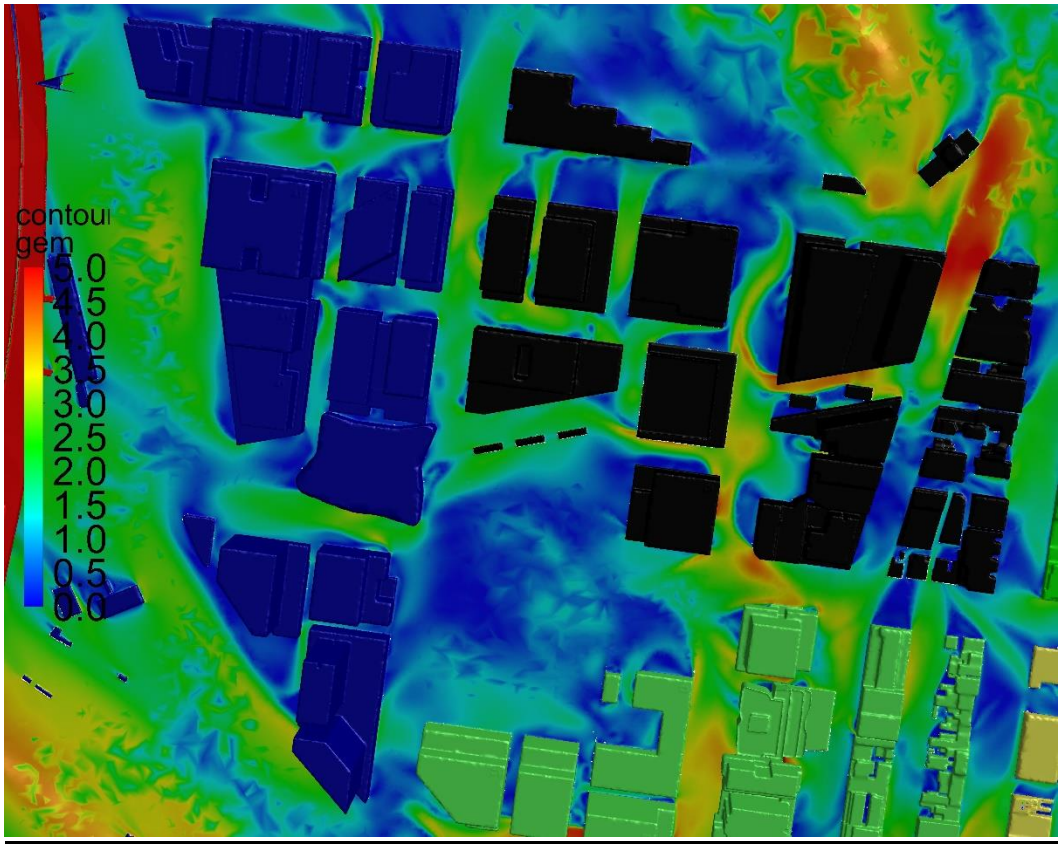
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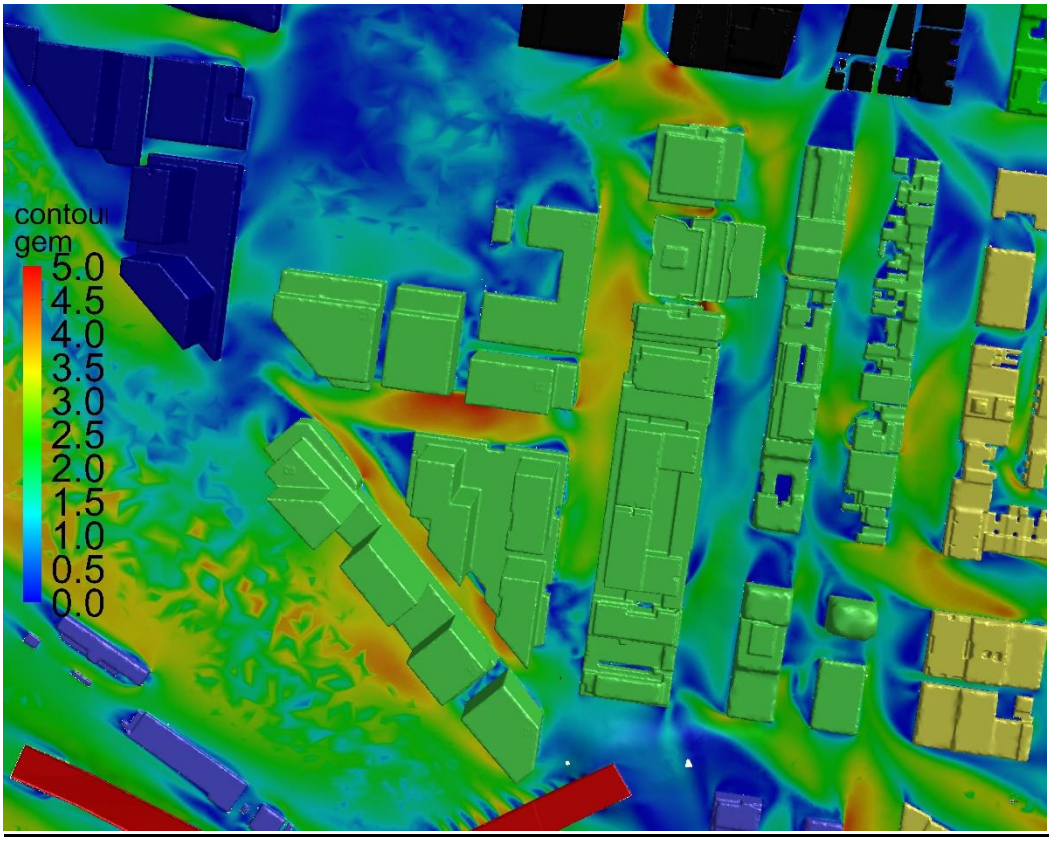
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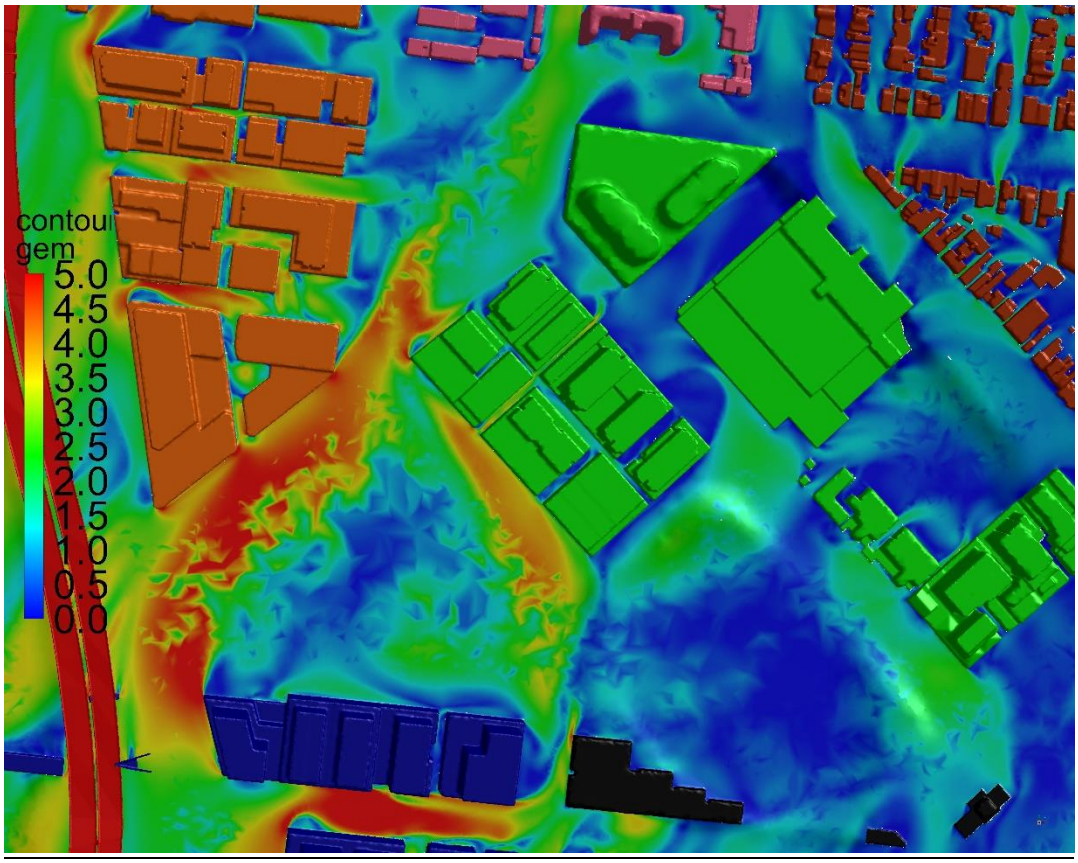
South: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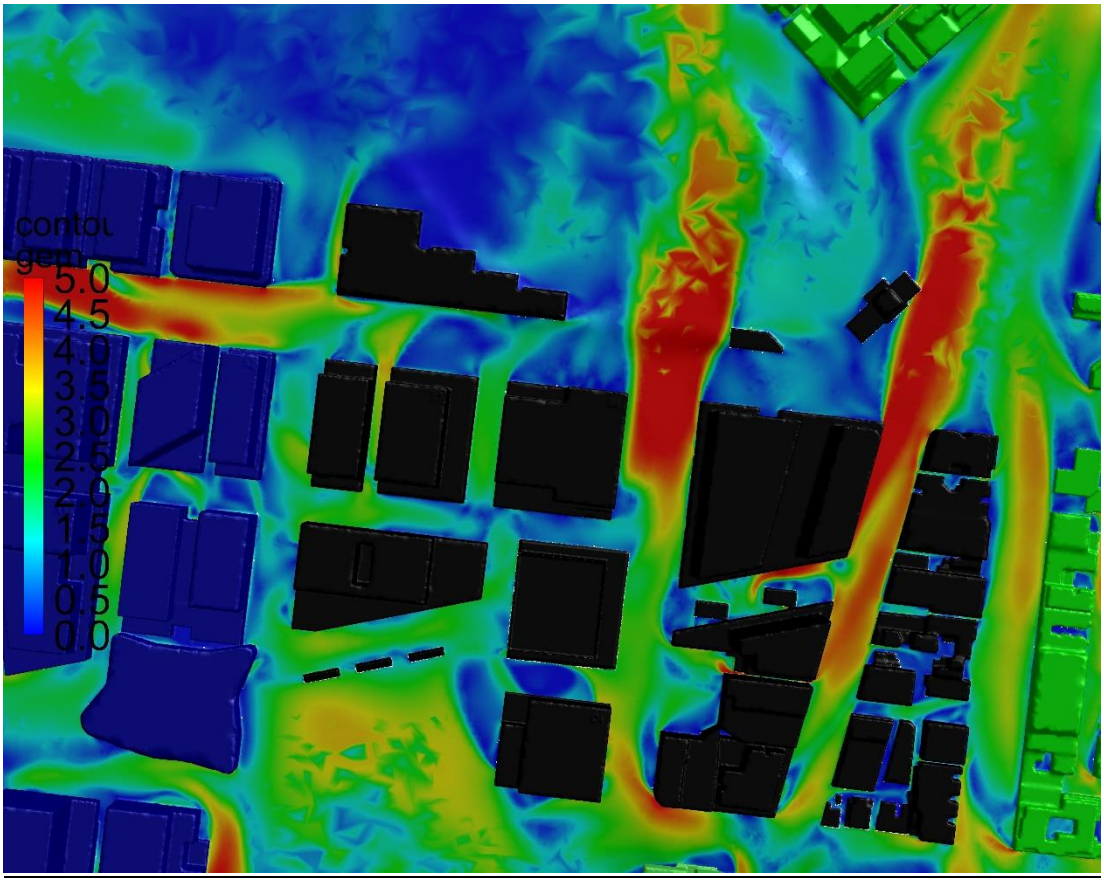
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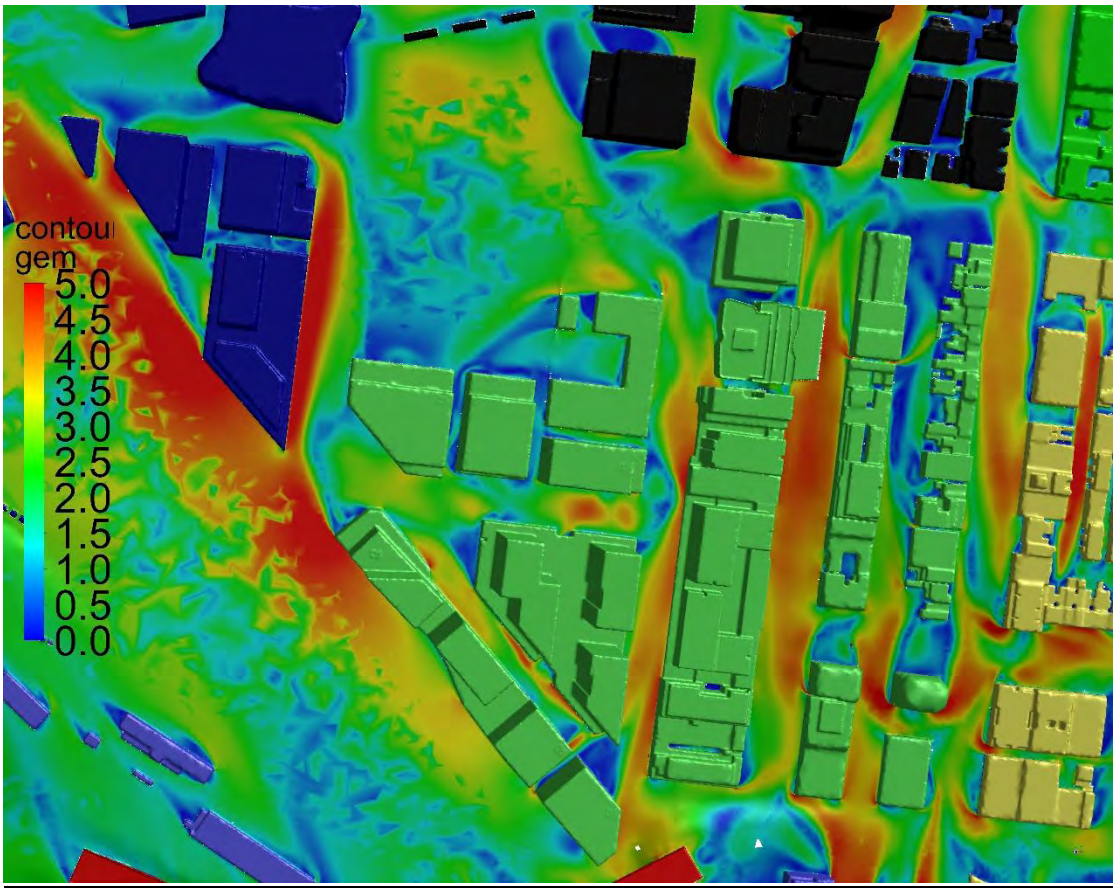
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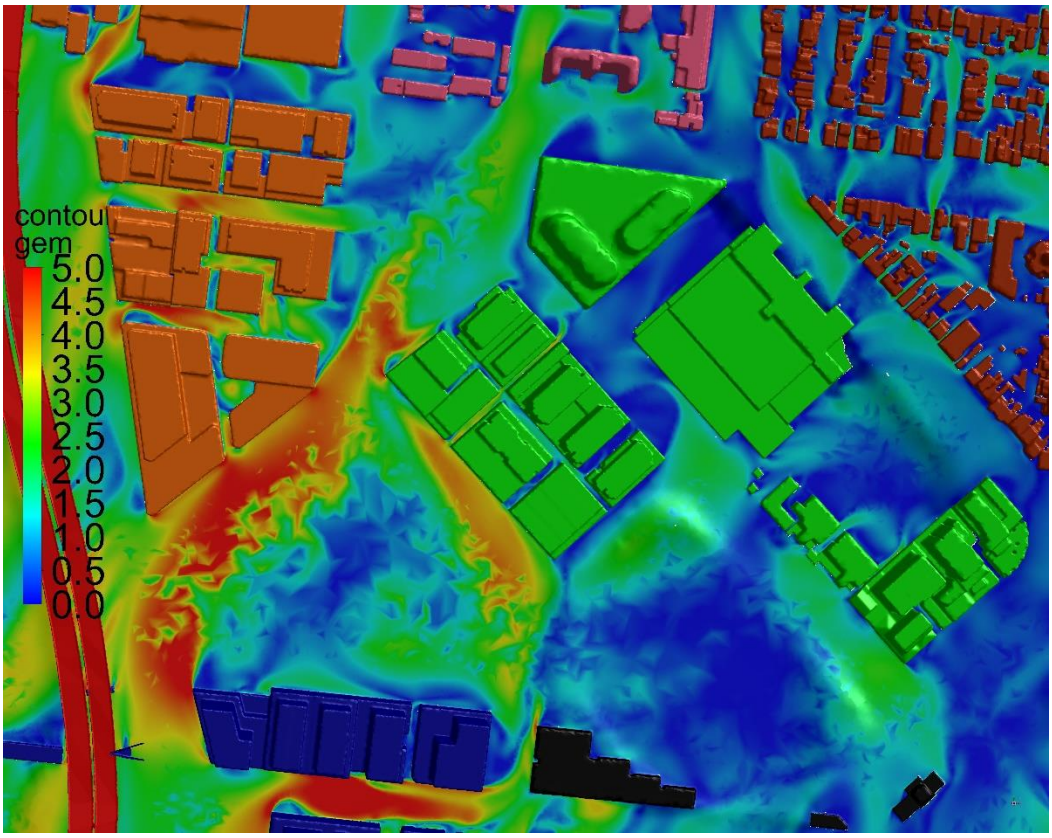
South West: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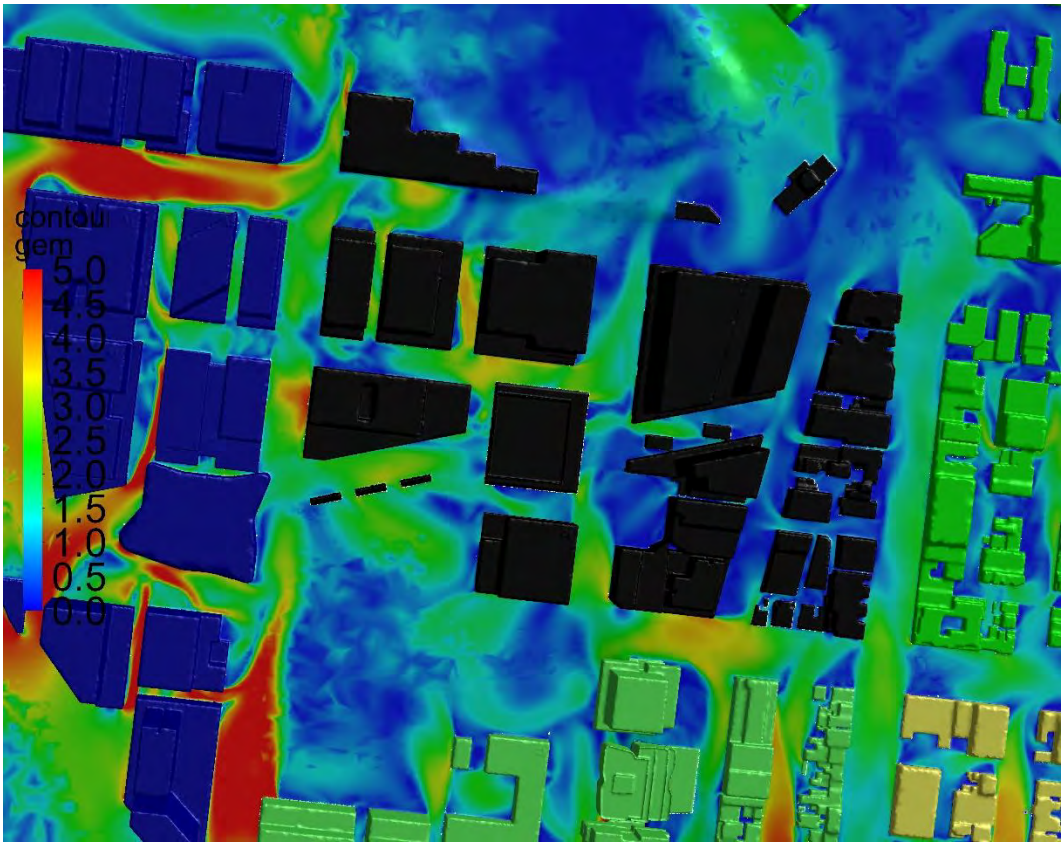
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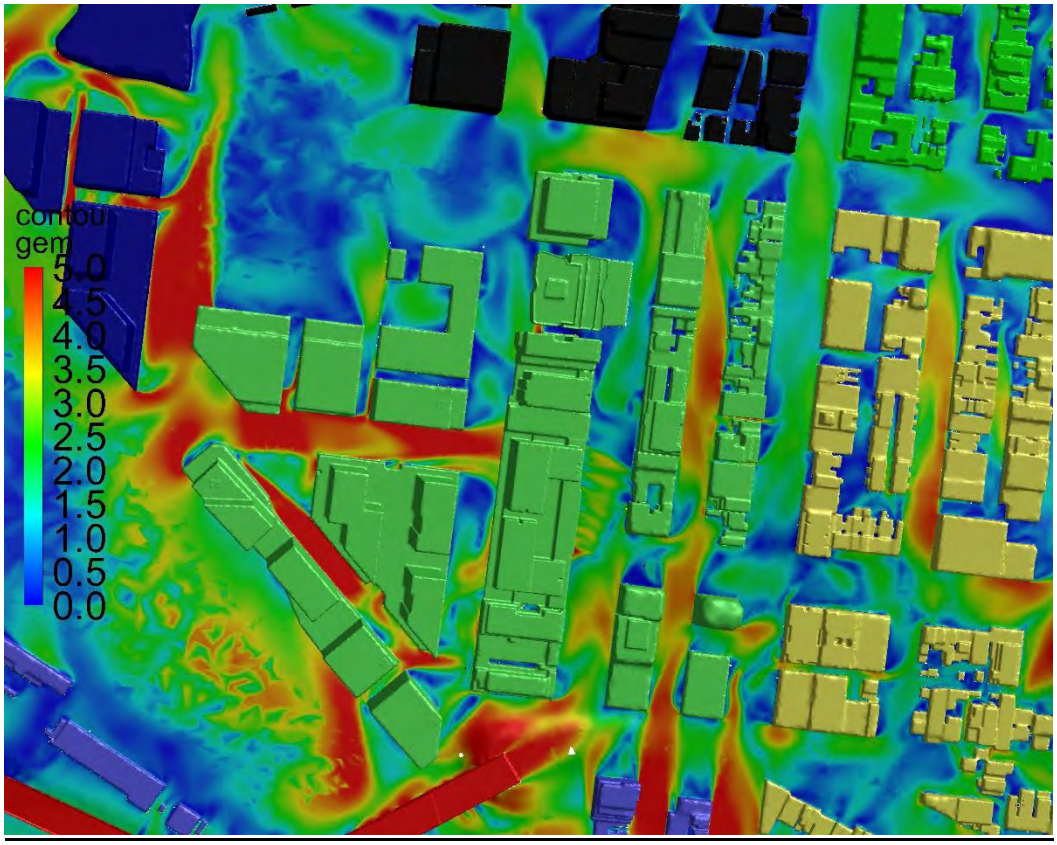
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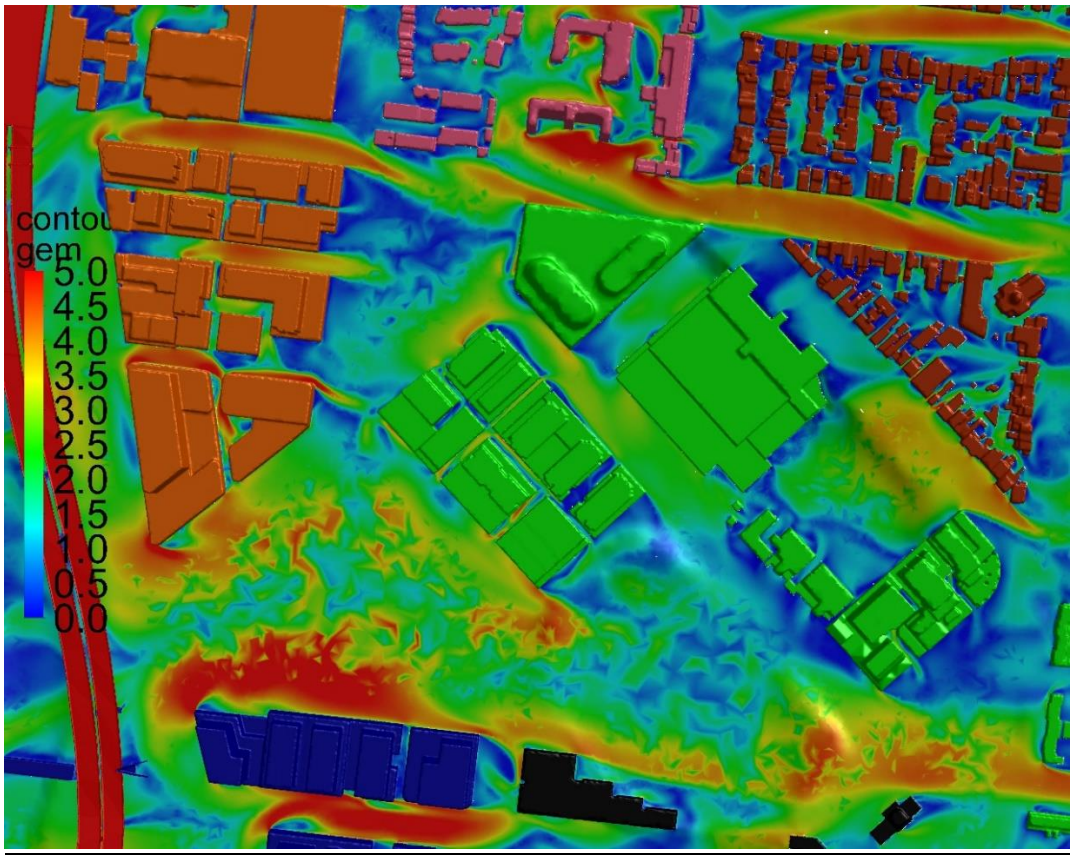
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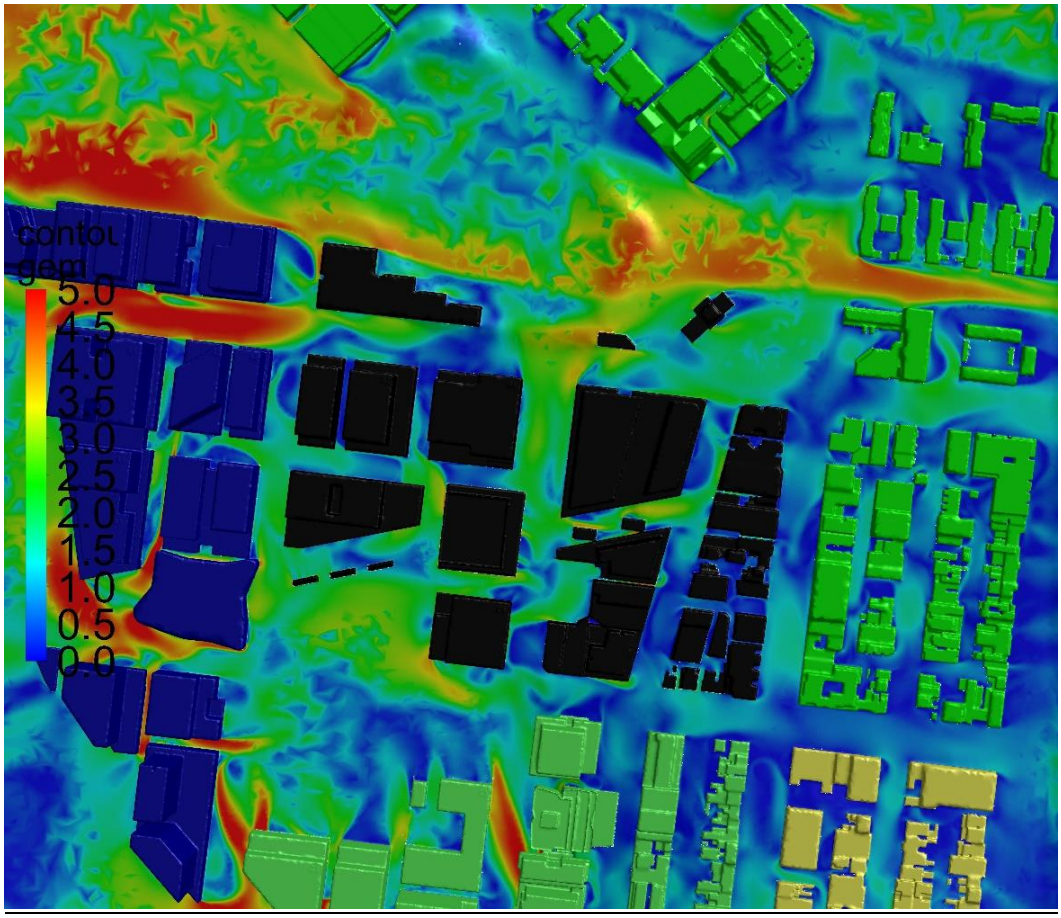
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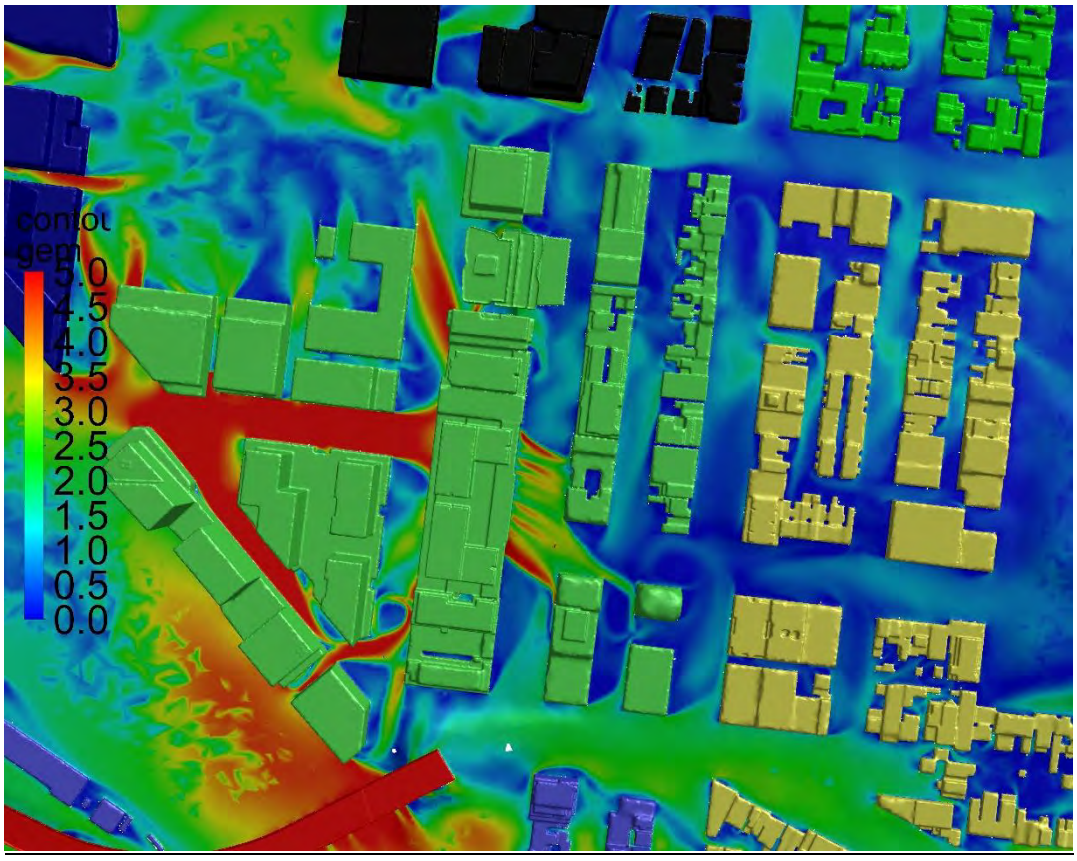
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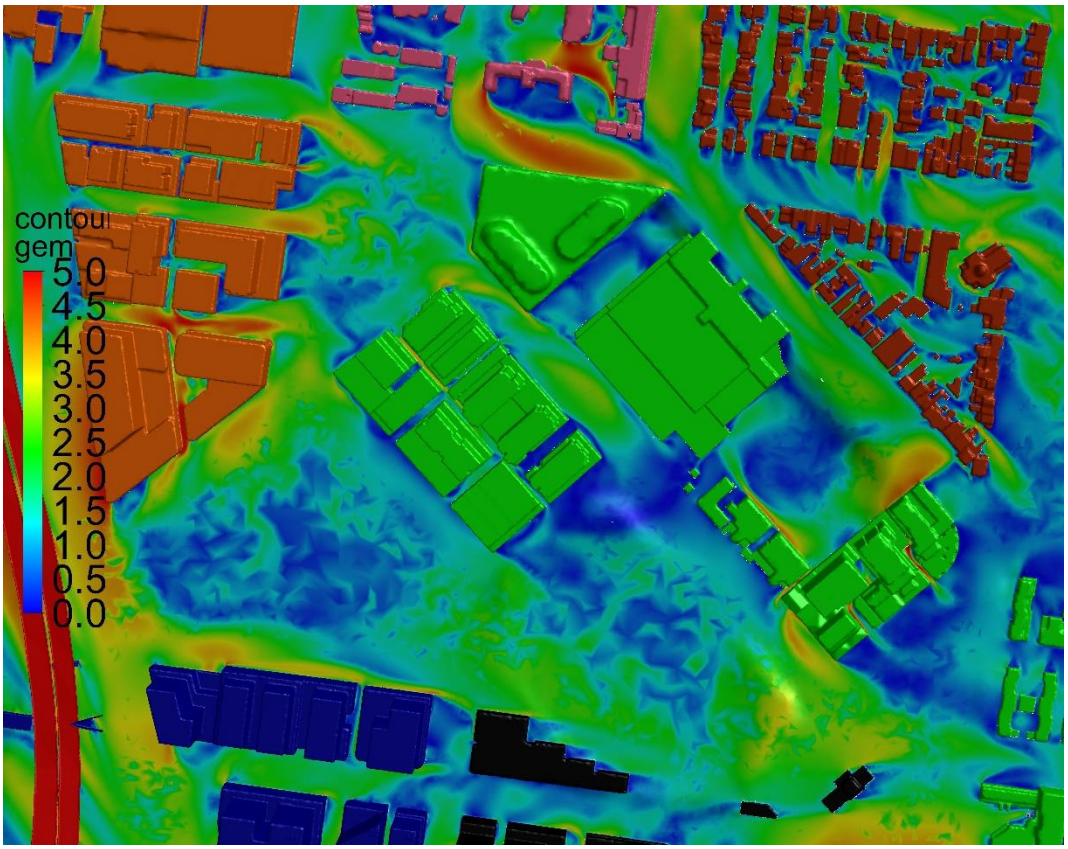
North West: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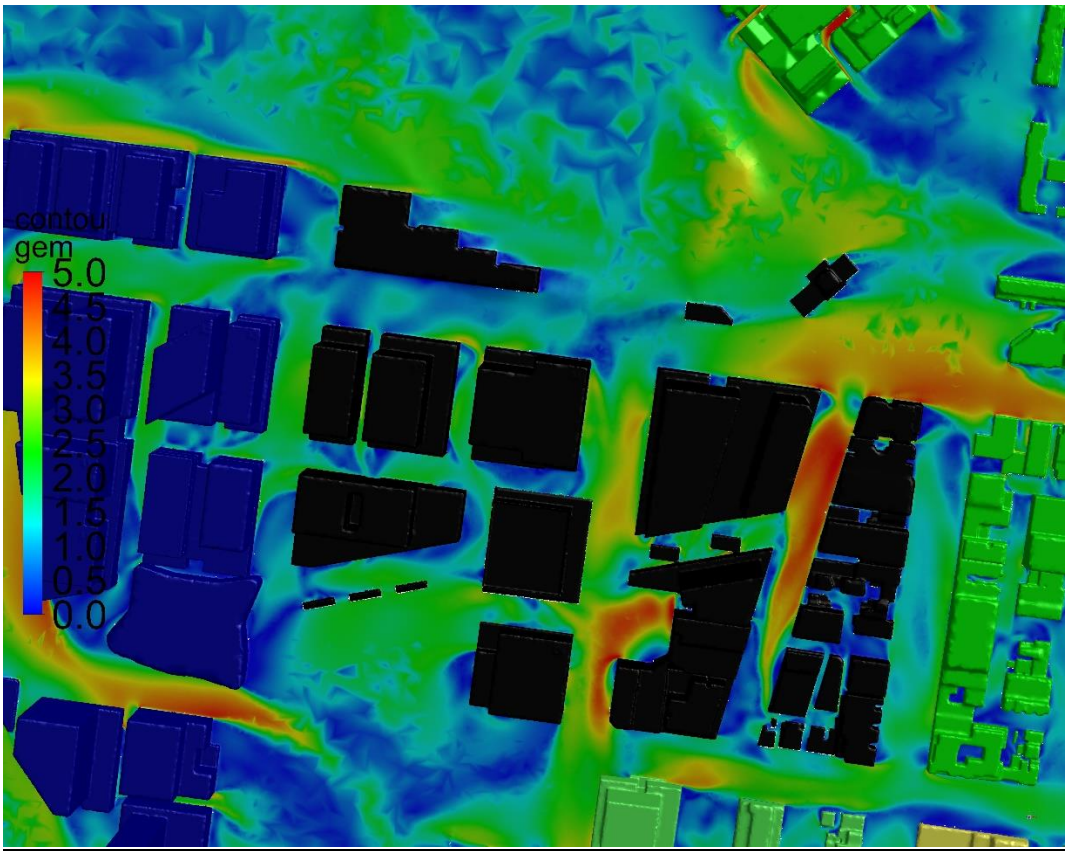
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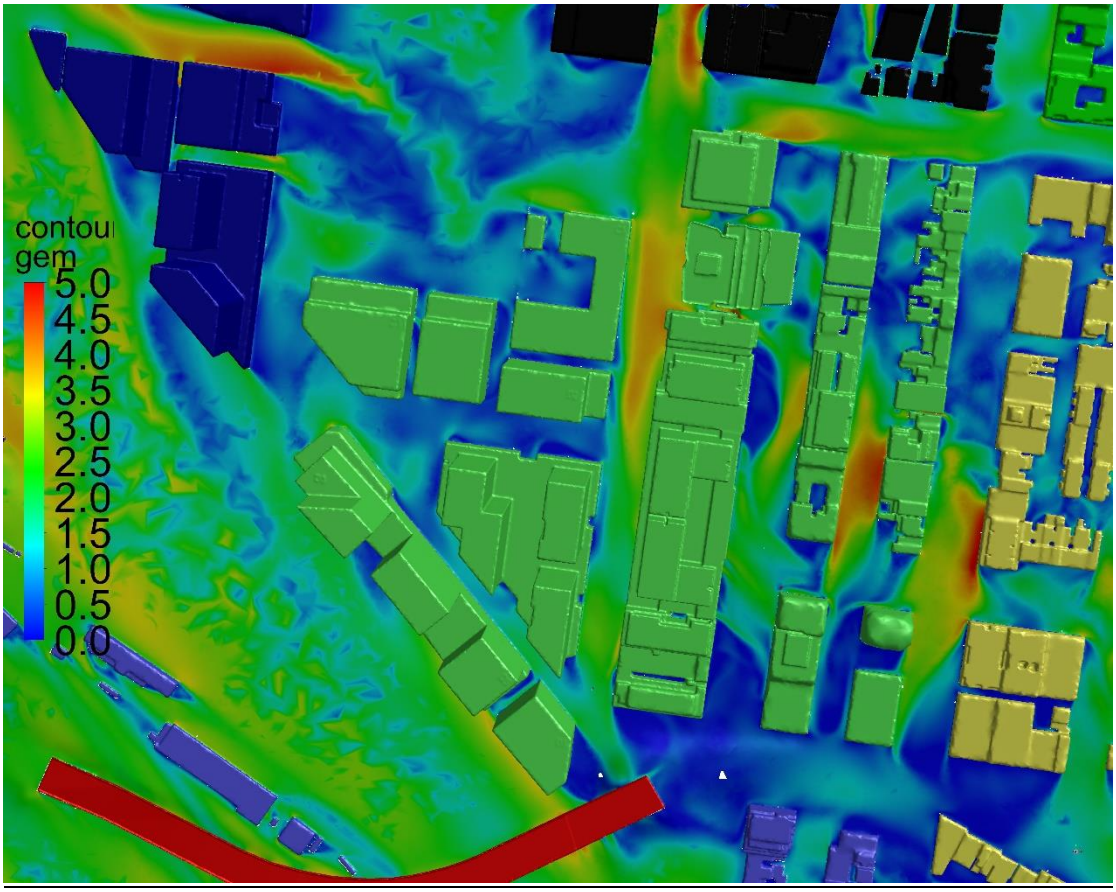
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