urban morphological analysis for wind potential

A P5 presentation for MSc Geomatics

by W. (Wessel) T. de Jongh - 2nd of July, 2021

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for Wind Potential
by Wessel de Jongh
MSc Geomatics, TU Delft

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“Wessel, what is Geomatics?”

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“Wessel, what is Geomatics?”

source: Google Earth

“Wessel, what is Geomatics?”

building

- location, time
- size: length x width x height
- function

source: Google Earth

“Wessel, what is Geomatics?”

source: Google Earth

road

- car and bike lane
- A to B
- material property

geomatics

“Wessel, what is Geomatics?”

Tools and technologies used to gather and analyse information to describe the built environment

source: Google Earth

building

- location, time
- size: length x width x height
- function

road

- car and bike lane
- A to B
- material property

urban morphology

describing the form, structure or fabric of the city

New York City *London* *Rome*

source: A. Jacobs, 1993

problem statement

Extensive research into wind flows in the urban environment

- influence of wind in the urban environment:
    i. Energy balance
    ii. Polution levels
    iii. Pedestrian comfort levels
    iv. Urban ventilation
    v. Urban Heat Island effect
    vi. Health and safety
- urban wind studies done consist mostly of:
    i. Computational Fluid Dynamics simulations
    ii. Scaled wind tunnel tests
    iii. Real-life street measurements
- these methods:
    i. are time consuming
    ii. depend on computational power
    iii. complex
    iv. limited by scale

frame of research

- wind flows from a morphological point of view (as opposed to an aerodynamic point of view)
- compute morphological parameters related to wind flows
- city scale
- compare with meteorological stations

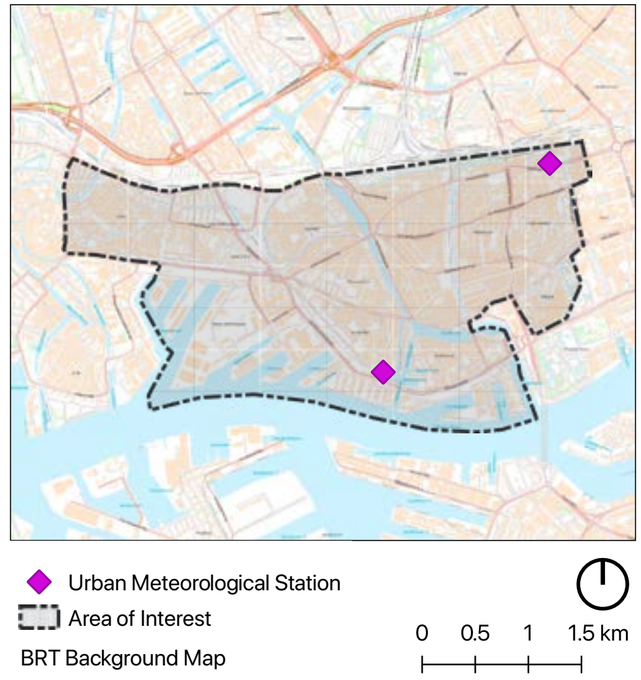
frame of research

The research will be focused on:

- area of interest in Rotterdam
- two meteorological stations by weather.tudelft.nl initiative
- two meteorological stations outside Rotterdam, used as reference stations

(KNMI & weather.tudelft.nl)

i. Area of Interest - Rotterdam



ii. Centrum station

iii. Delfshaven station

source: i. BRT, ii. & iii. weather.tudelft.nl

research objective

Main research question:

Can we use urban morphology to automatically calculate potential increase in wind velocity?

With subquestions:

i. How do different morphological parameters relate to wind velocity?
ii. How can we develop a methodology to compute multiple morphological parameters?
iii. Is this method suitable for identifying potentially increased wind velocity situations?
iv. Can we use measurements from meteorological stations to validate the methodology?

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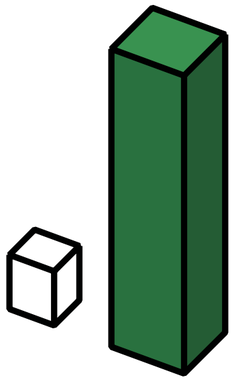
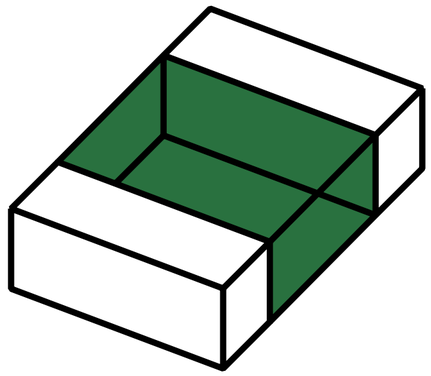
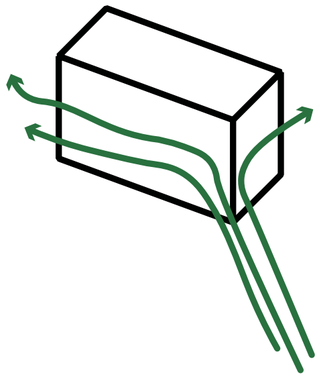
related works



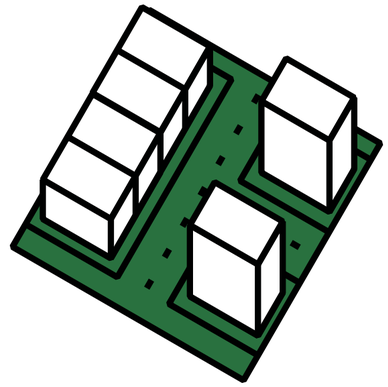
i. Tall buildings



ii. Urban canyon



iii. Wind direction



iv. Terrain roughness length

relevant flows

Wind regime when flow encouters a tall building:

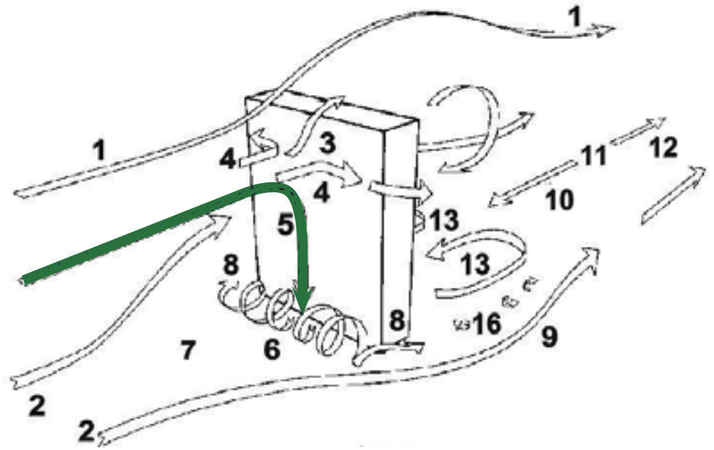
- flow hits windward side of the building and a big portion is pushed downward (5)
- a circulating vortex is created at pedestrian level (6)
- when the circulating vortex reaches the side of the building (8) it joins the main flow (2) and accelerates (9)
- behind the building, transient wind flow patterns arise (10, 11, 12, 13) and are linked to lower wind velocities

The lateral high wind speed zone (9) increases with building height

Related parameters:

- height
- wind- and leeward

i.



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source: i. Beranek and Koten, 1979. ii. Tsang et al., 2012

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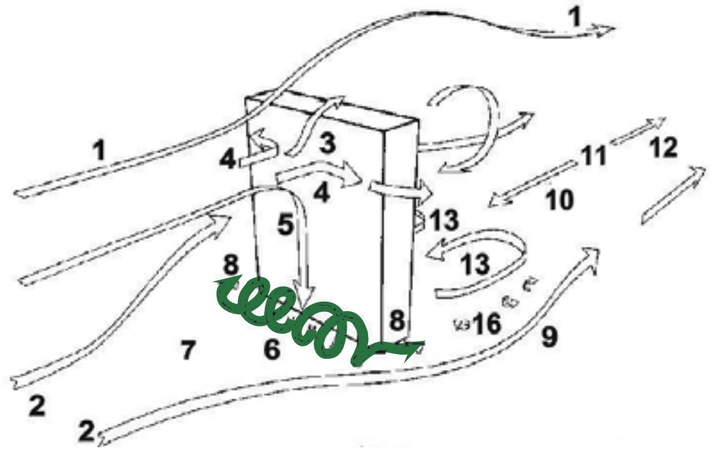

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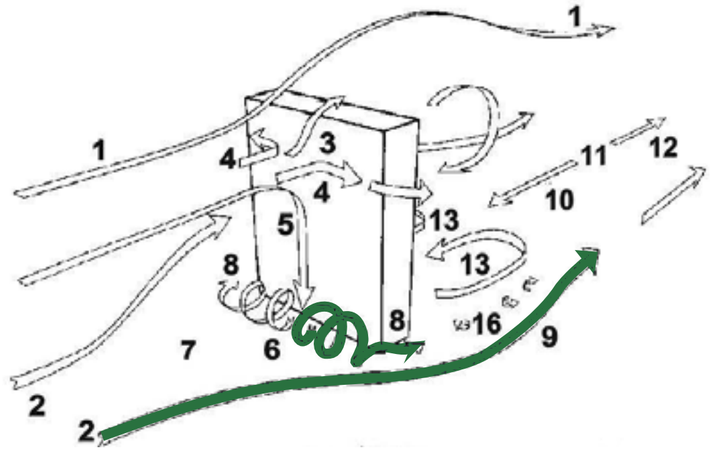

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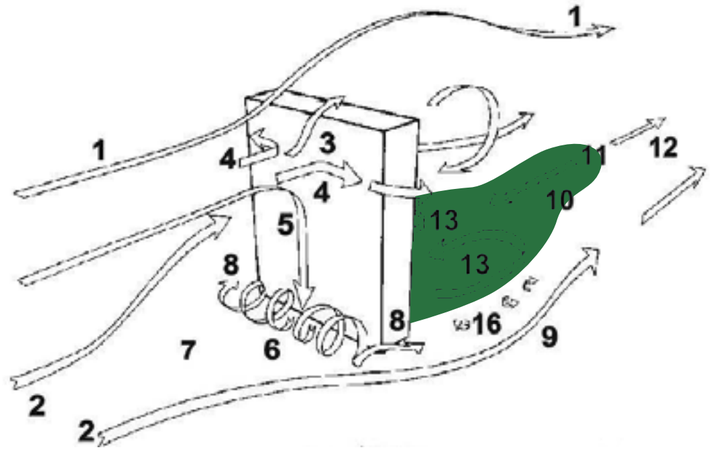

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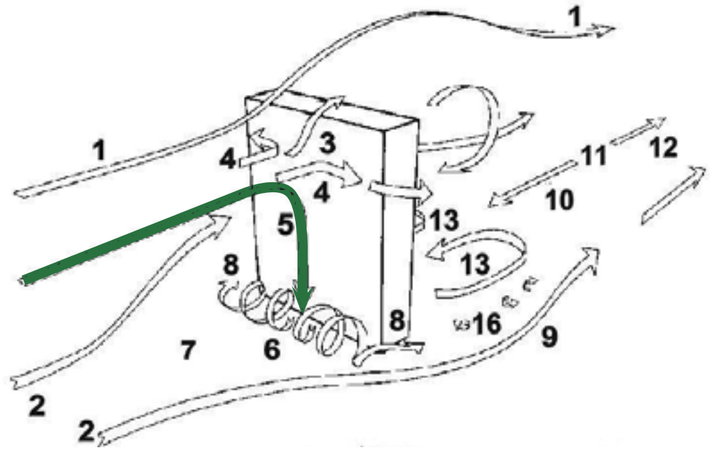

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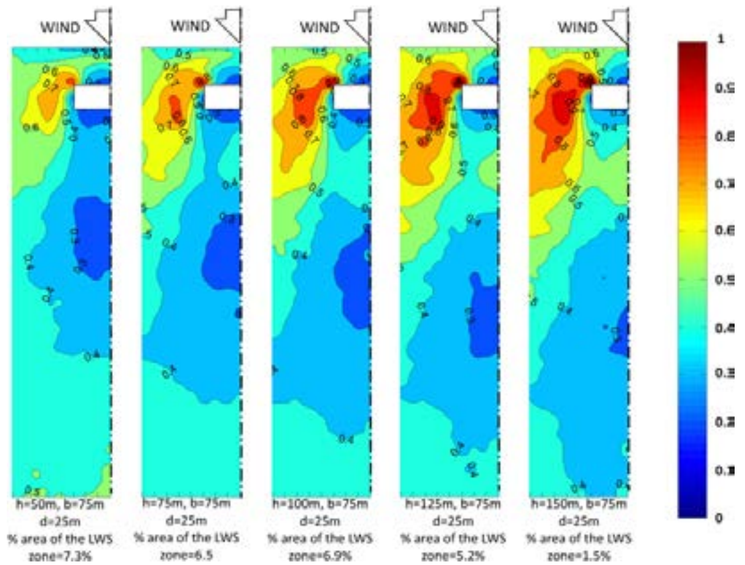


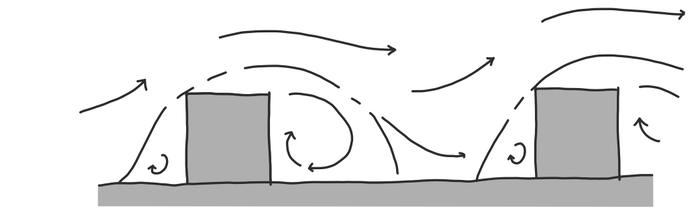
source: i. Beranek and Koten, 1979. ii. Tsang et al., 2012

relevant flows

- urban canyon is defined by height (H), width (W) and length (L)
- different flow regimes depending on the ratio between them
    i. isolated roughness flows
    ii. wake interference flow
    iii. skimming flow

Related parameters:

- height
- width
- length



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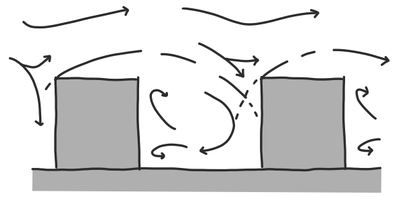

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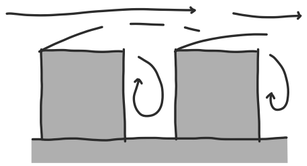
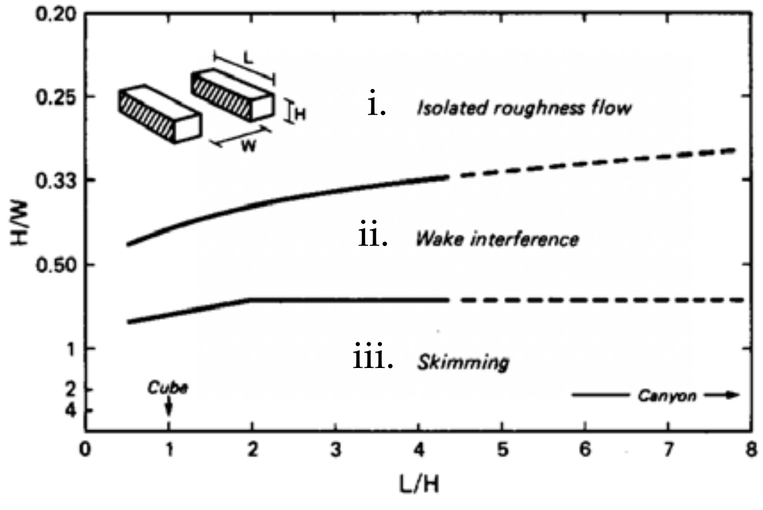


iii.



source: Oke [1988]

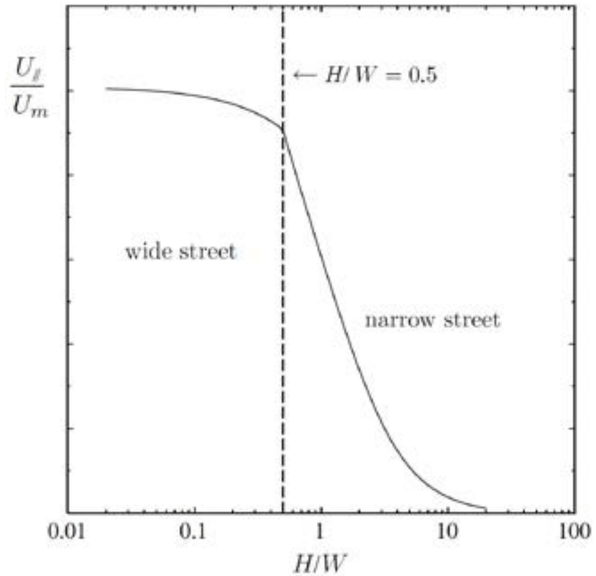
relevant flows

- high H/W ratio linked to decreased wind velocity

Related parameters:

- height
- width
- length

Dimensionless longitudinal mean velocity as a function of H/W for flow parallel to the street



source: Soulhac et al., 2008

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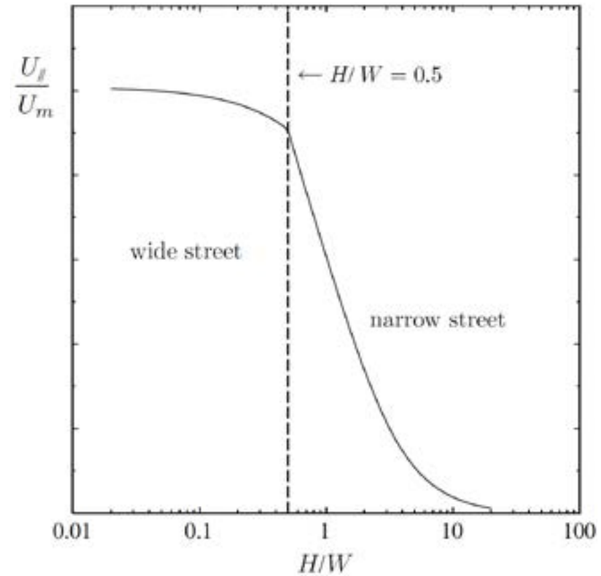
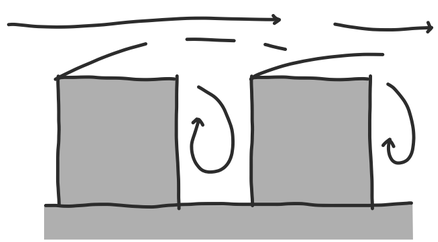
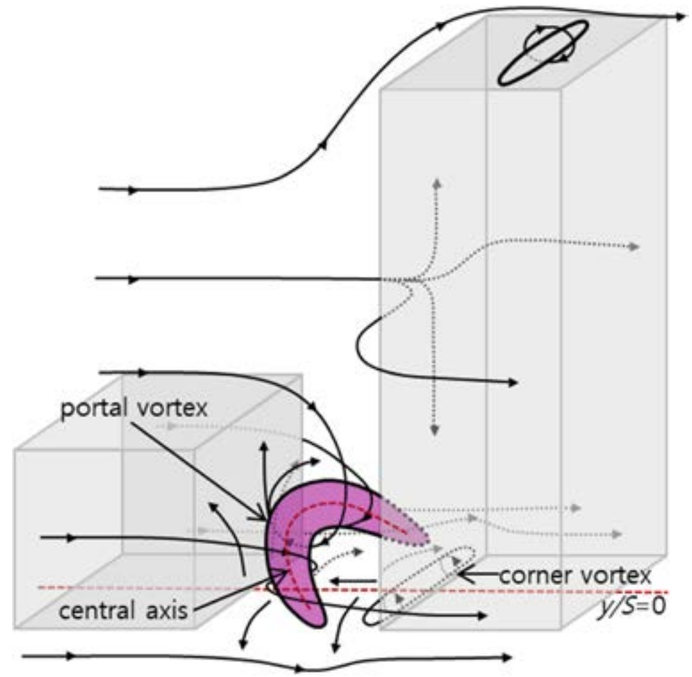




source: Soulhac et al., 2008

relevant flows

- asymetry in the urban canyon causes flows to behave differently.
- a portal shaped vortex spans the canyon lengths



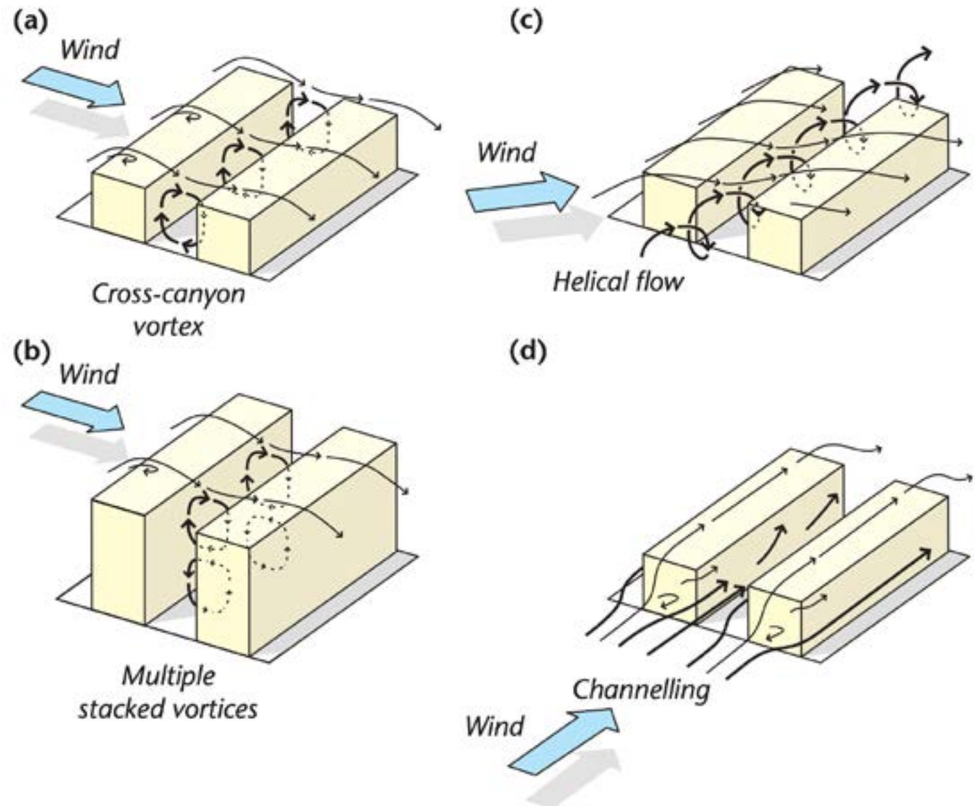
Related parameters:

- height
- width
- length
- wind- and leeward

source: Park et al. [2019]

relevant flows

- wind direction also changes flows in the canyon



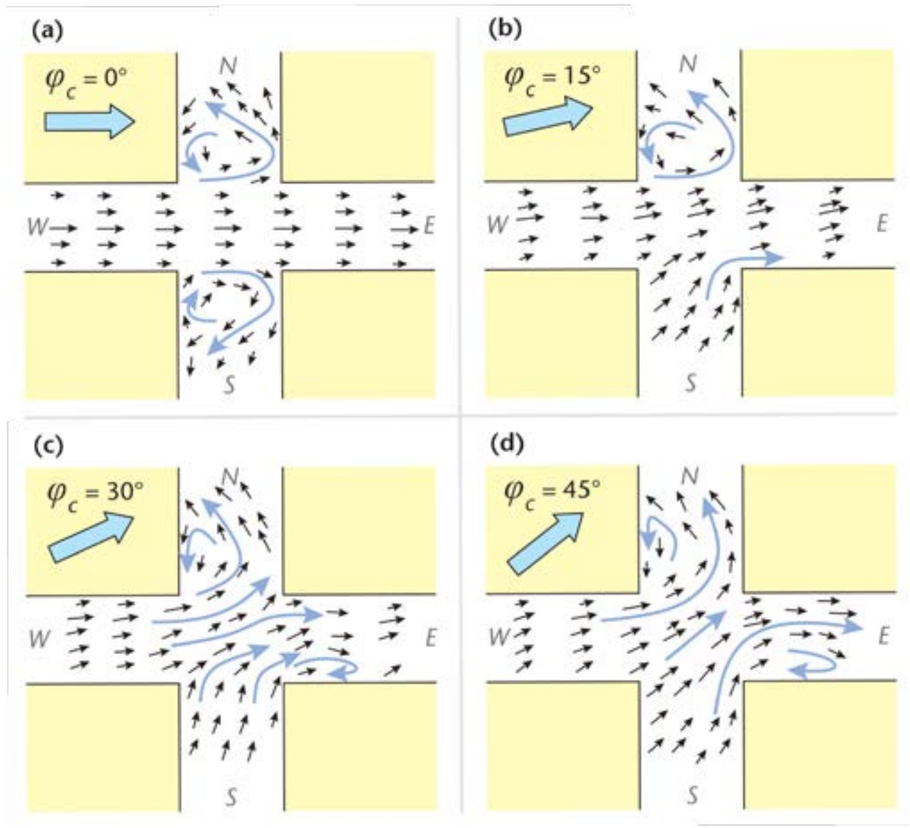
Related parameters:

- height
- width
- length
- wind- and leeward
- angle of attack

source: Oke et al., 2017

relevant flows

- angle between the street and the buildings



Related parameters:

- angle of attack

source: Oke et al., 2017. Soulhac et al., 2009

terrain roughness length

- value to indicate roughness of terrain
- terrain material characterstics cause drag and increase turbulance
- higher roughness length value means lower potential wind velocity

Related parameters:

- roughness length

Table 4.
Davenport roughness classification (revised).

z_0 (m)	Landscape description
1: 0.0002 "**Sea**"	Open sea or lake (irrespective of the wave size), tidal flat, snow-covered flat plain, featureless desert, tarmac and concrete, with a free fetch of several kilometers.
2: 0.005 "**Smooth**"	Featureless land surface without any noticeable obstacles and with negligible vegetation; e.g. beaches, pack ice without large ridges, morass, and snow-covered or fallow open country.
3: 0.03 "**Open**"	Level country with low vegetation (e.g. grass) and isolated obstacles with separations of at least 50 obstacle heights; e.g. grazing land without windbreaks, heather, moor and tundra, runway area of airports.
4: 0.10 "**Roughly open**"	Cultivated area with regular cover of low crops, or moderately open country with occasional obstacles (e.g. low hedges, single rows of trees, isolated farms) at relative horizontal distances of at least 20 obstacle heights.
5: 0.25 "**Rough**"	Recently-developed "young" landscape with high crops or crops of varying height, and scattered obstacles (e.g. dense shelterbelts, vineyards) at relative distances of about 15 obstacle heights.
6: 0.5 "**Very rough**"	"Old" cultivated landscape with many rather large obstacle groups (large farms, clumps of forest) separated by open spaces of about 10 obstacle heights. Also low large vegetation with small inter-spaces, such as bushland, orchards, young densely-planted forest.
7: 1.0 "**Closed**"	Landscape totally and quite regularly covered with similar-size large obstacles, with open spaces comparable to the obstacle heights; e.g. mature regular forests, homogeneous cities or villages.
8: ≥ 2 "**Chaotic**"	Centres of large towns with mixture of low-rise and high-rise buildings. Also irregular large forests with many clearings.

source: Wieringa, 1992

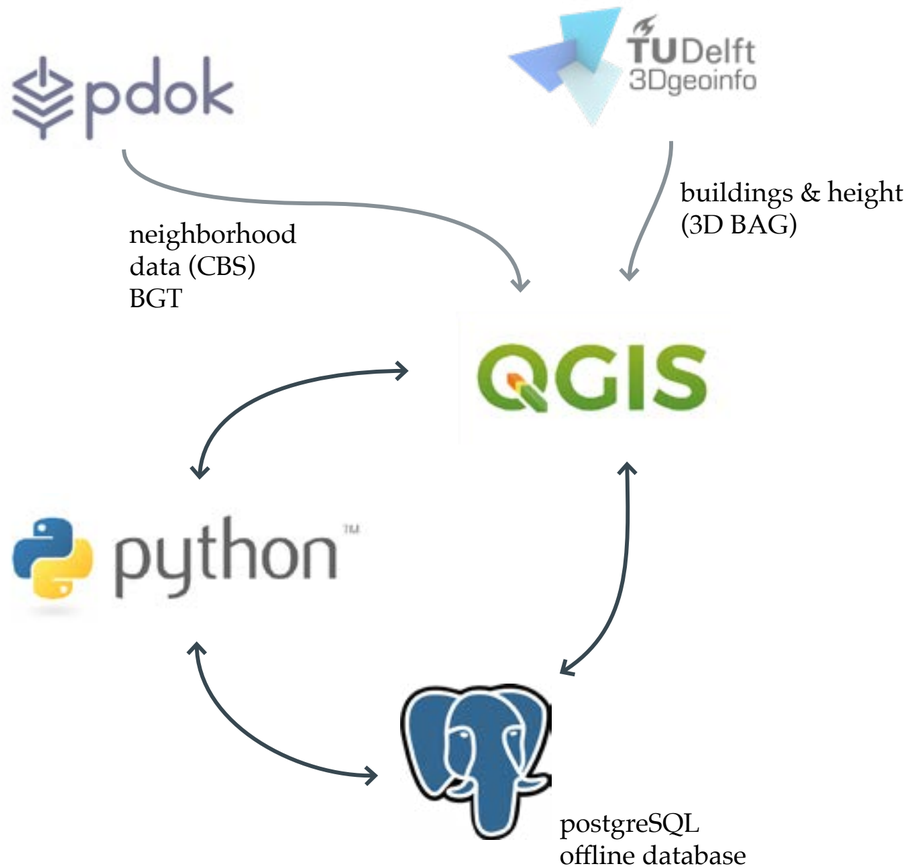
relevant parameters

- height
- width
- length
- wind- and leeward
- angle of attack
- roughness length

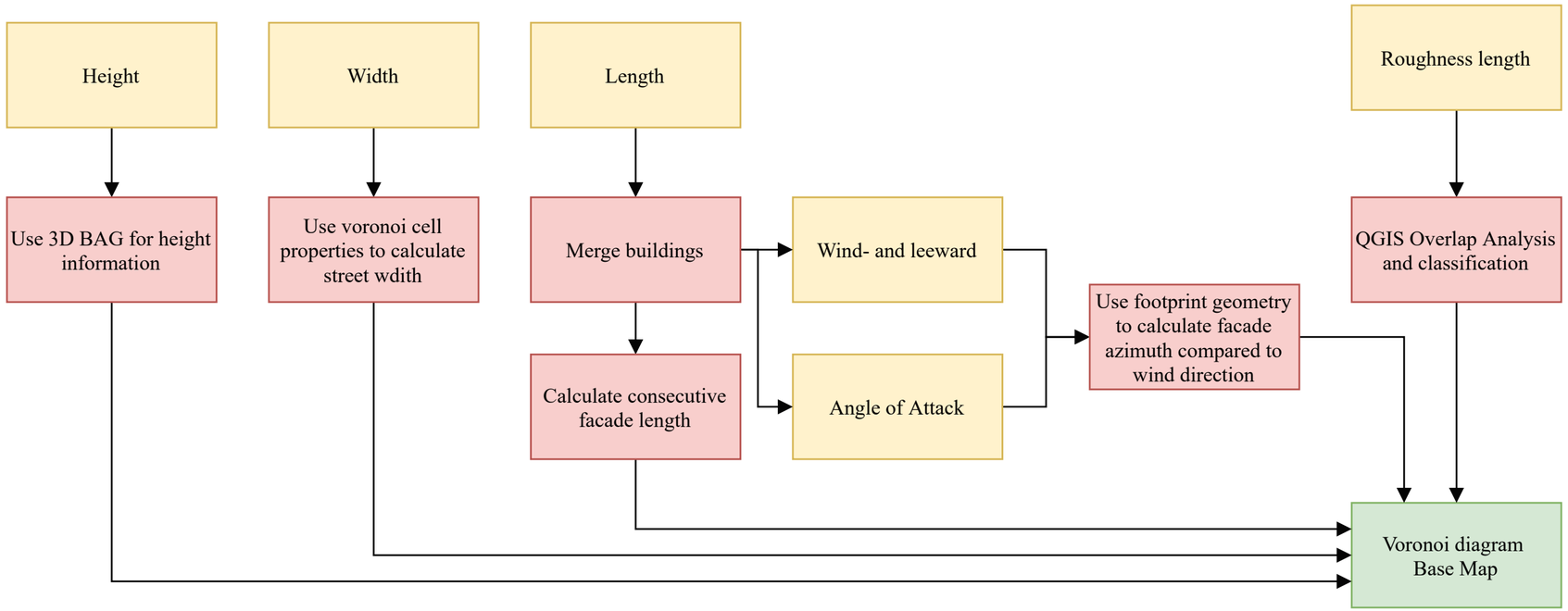
Urban Morphological Analysis for Wind Potential

by Wessel de Jongh
MSc Geomatics, TU Delft

tools and data



flowchart


Height
Width
Length
Roughness length
Use 3D BAG for height information
Use voronoi cell properties to calculate street wdith
Merge buildings
Wind- and leeward
Use footprint geometry to calculate facade azimuth compared to wind direction
QGIS Overlap Analysis and classification
Calculate consecutive facade length
Angle of Attack
Voronoi diagram Base Map

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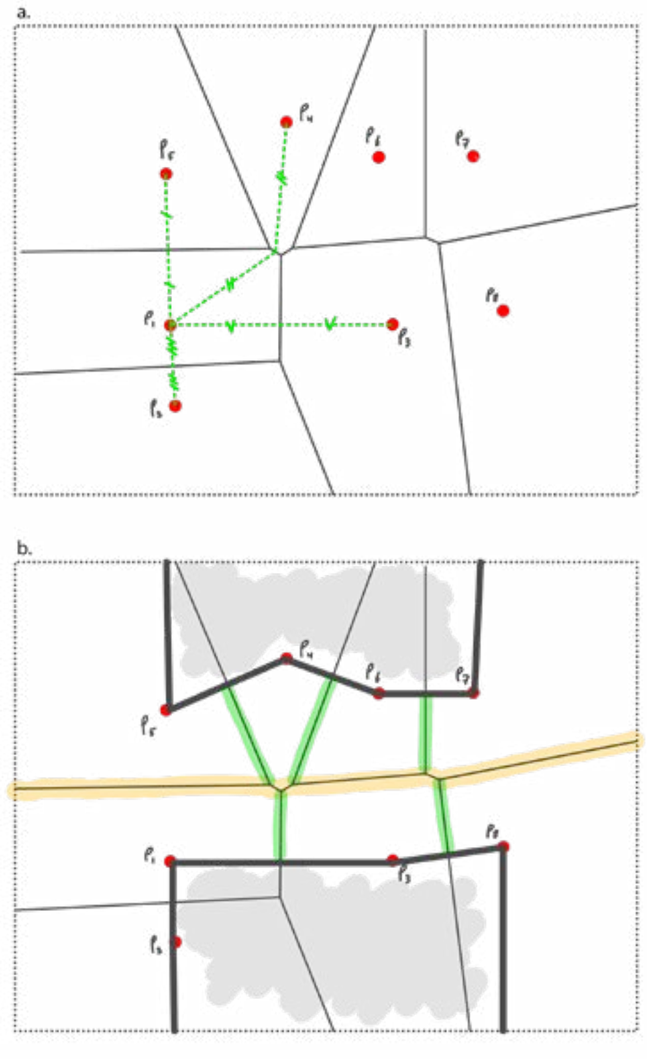
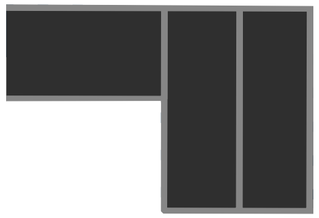
voronoi diagram

- input Points
- creates Voronoi cells based on distance to other Points
- Edges describe the middle of two Points

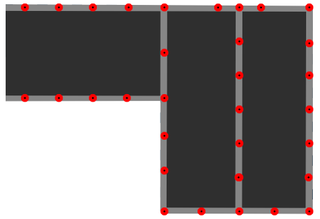


voronoi diagram

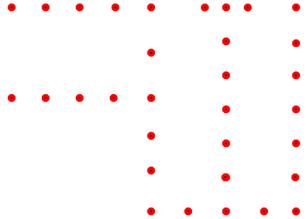
- the building footprints are converted to points and used as input for a voronoi diagram



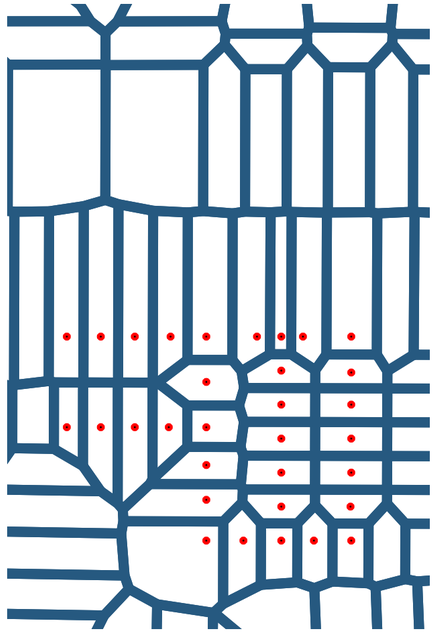
1. buildings



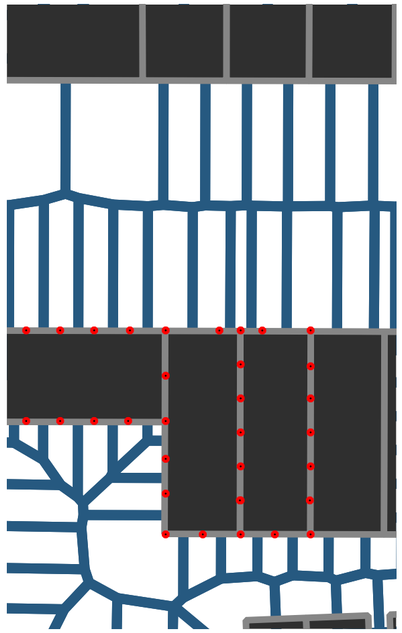
2. convert to points



3. points



4. create the voronoi diagram



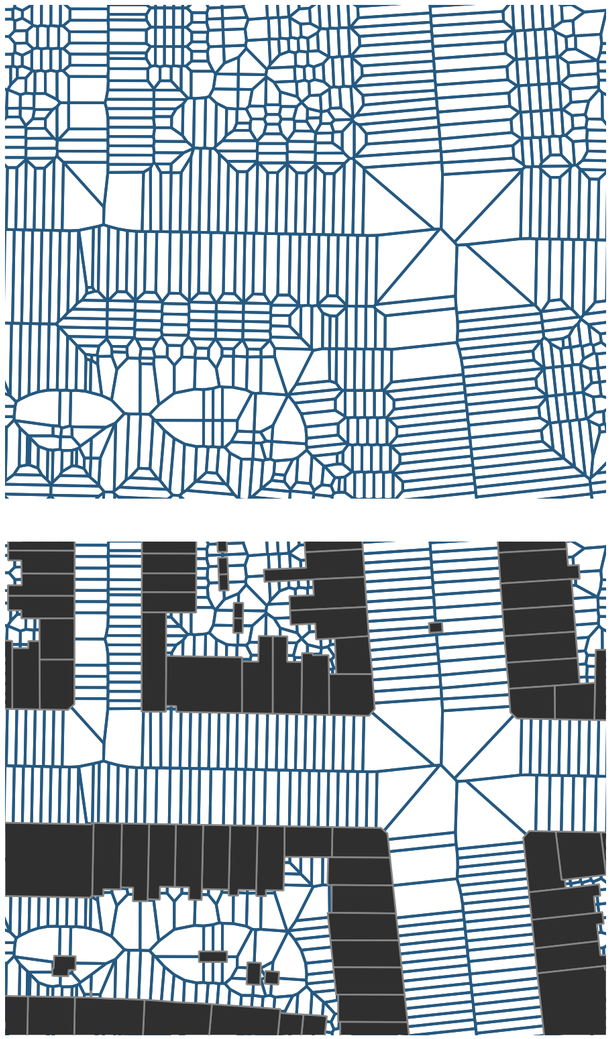
5. result

voronoi diagram

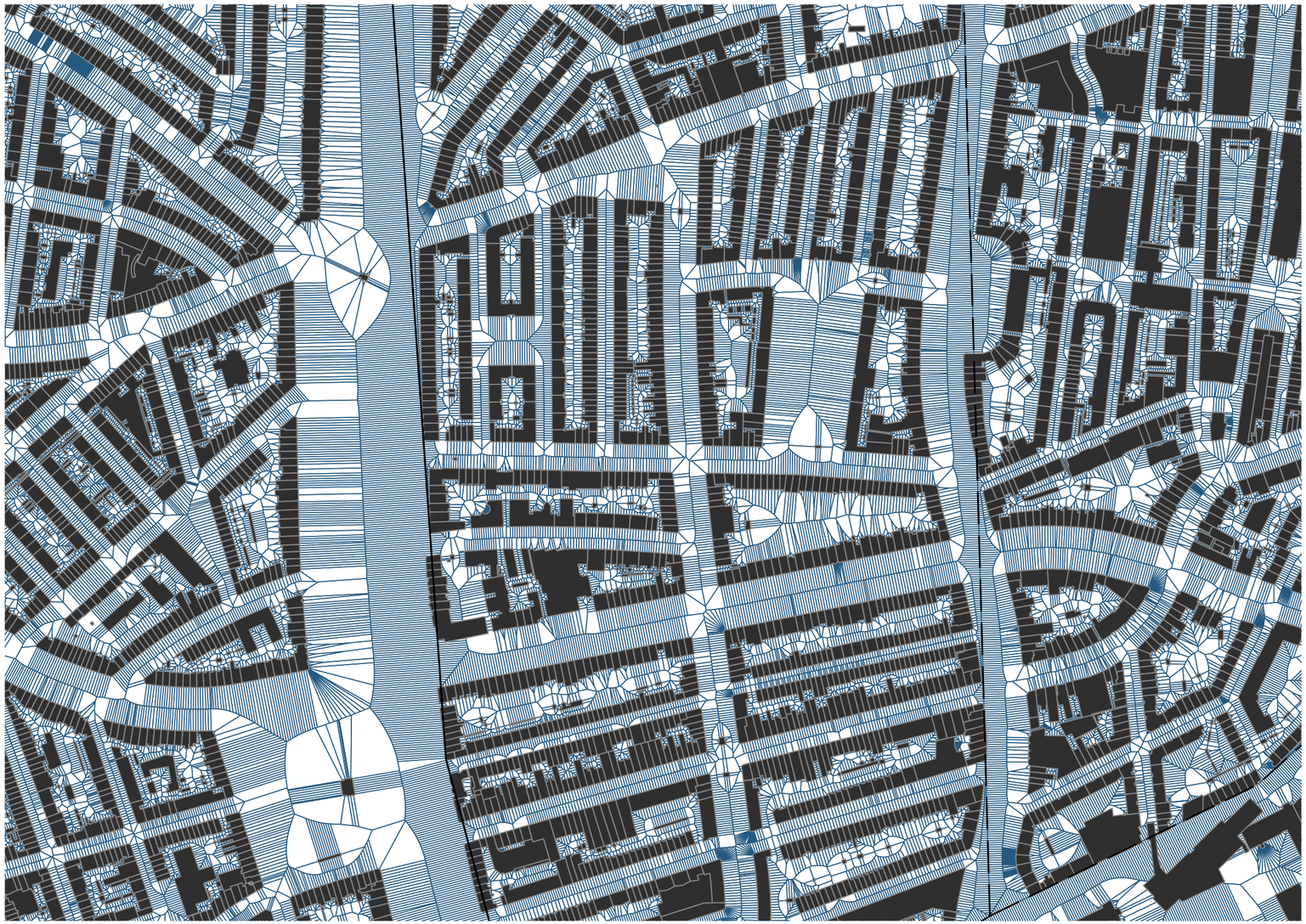
Many lines, many cells

Important characteristics:

- they meet in the middle of the street
- perpendicular to the facade
- are uniform in shape where facades line up



voronoi diagram



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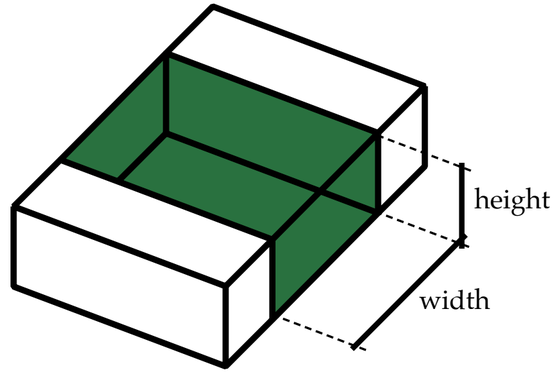
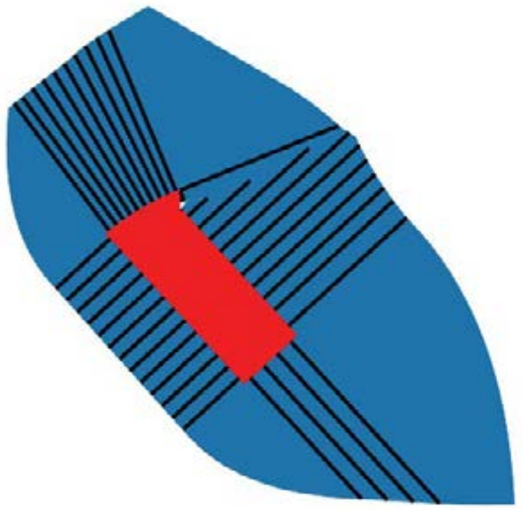
voronoi diagram

canyon height and width

- height from the buildings and add to cells
- width from the edges of the Voronoi cells

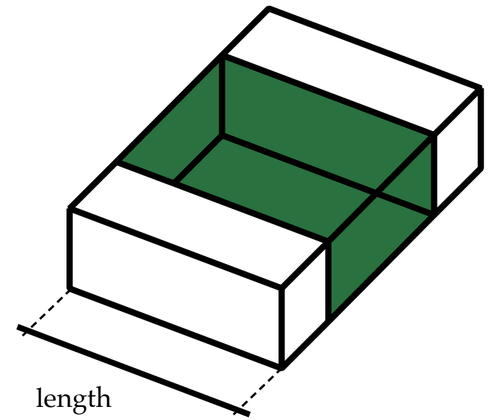


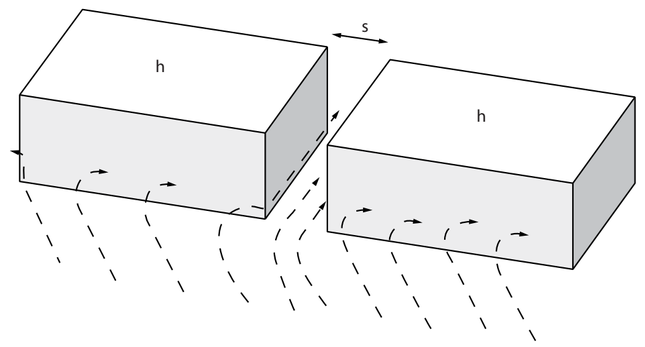
- select **building**
  i. select intersecting **edges**
  ii. select intersecting **cells**
- calculate the length of the **edge** ⟶ canyon width
- add **building height** and **canyon width** to **cells**



canyon length

- street network dataset
- gaps between buildings





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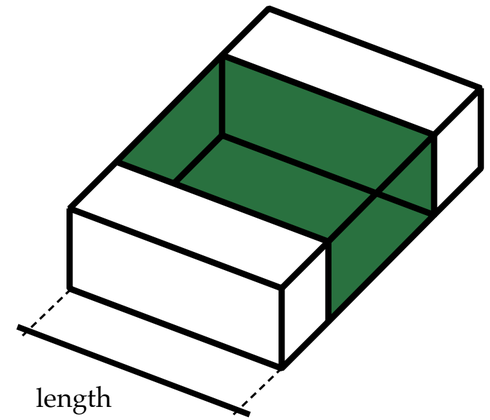

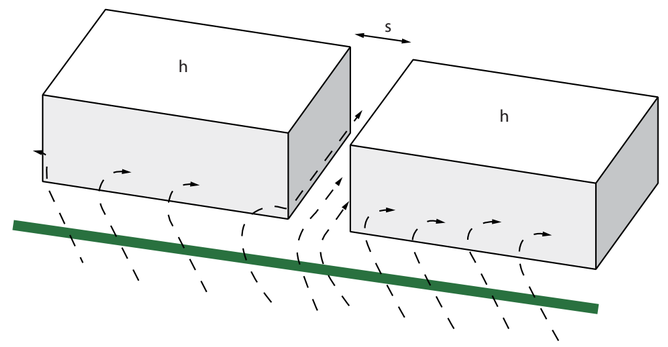

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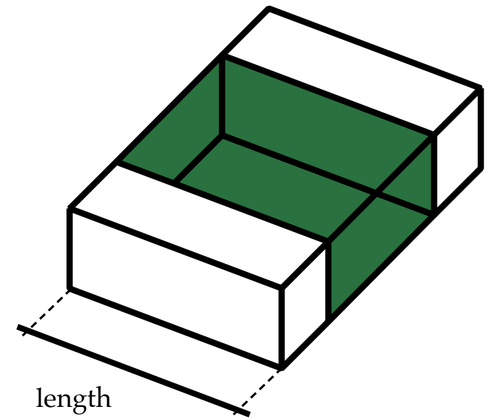
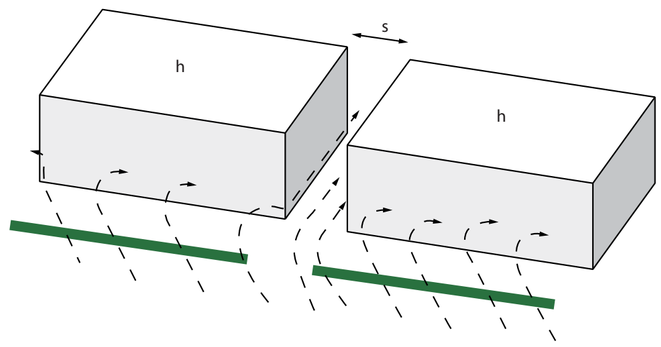
canyon length

- street network dataset
- gaps between buildings
- individual buildings





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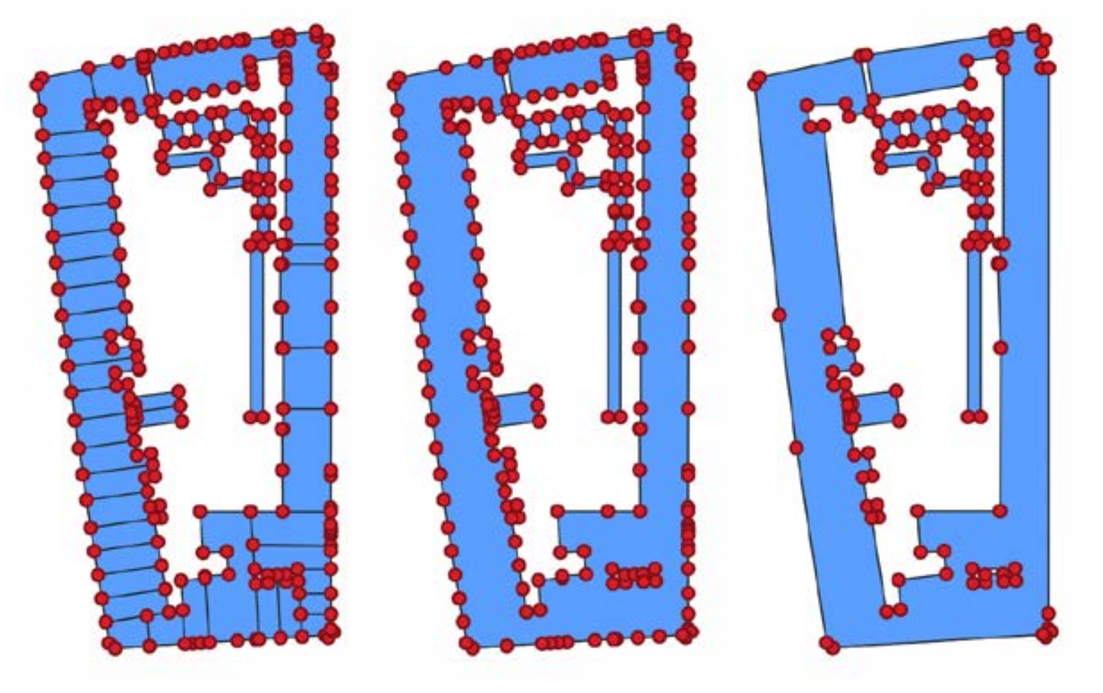
by Wessel de Jongh
MSc Geomatics, TU Delft

canyon length

- merge individual buildings into blocks



i. ii. iii.

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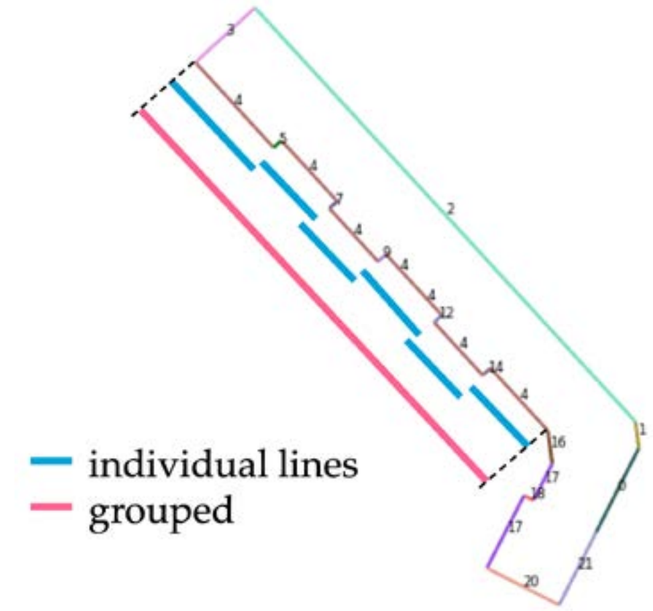
canyon length

- groups similar lines based on orientation ⟶ **canyon length**



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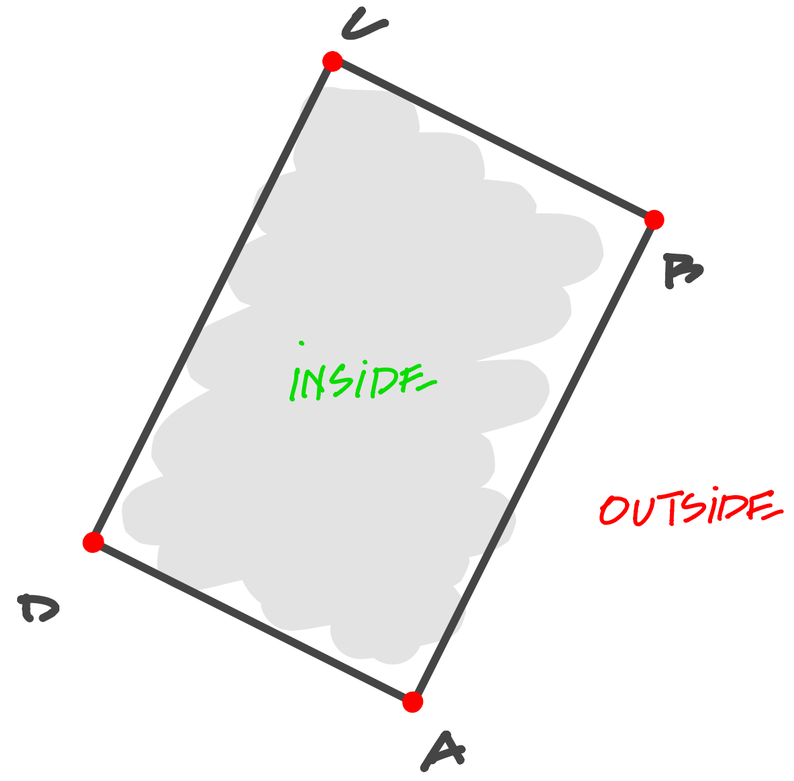
windward

- depending on the wind direction, which facades are hit by wind?

1. establish inside - outside relationship



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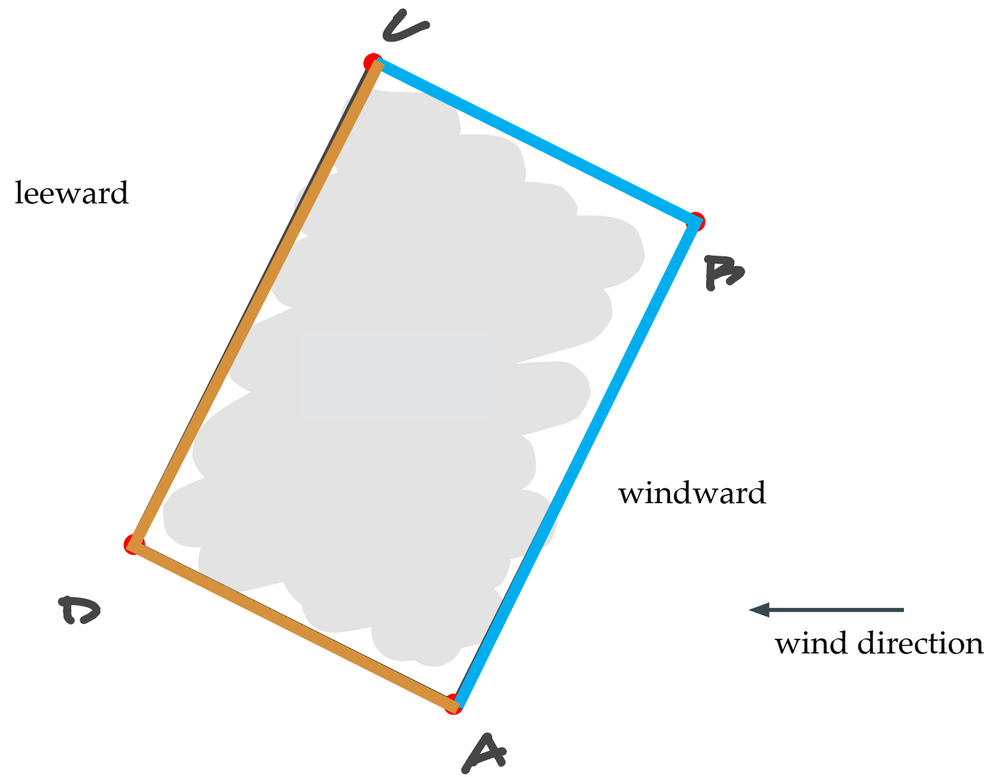
windward

- depending on the wind direction, which facades are hit by wind?

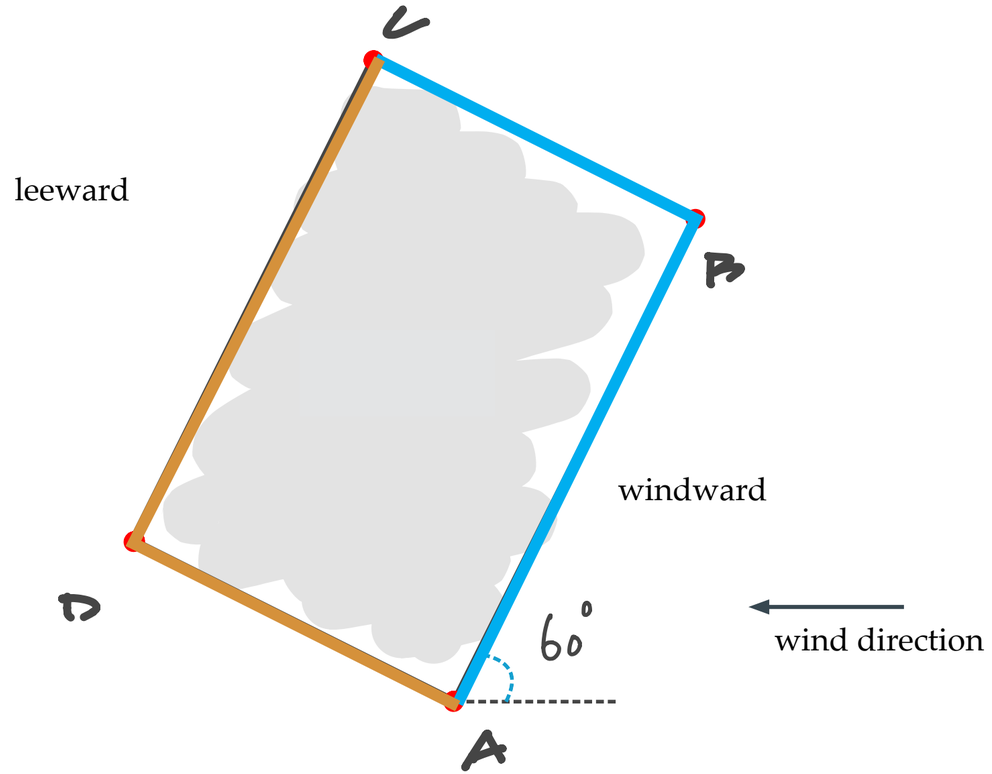
1. establish inside - outside relationship
2. determine wind- and leeward side



angle of attack

- depending on the wind direction, which facades are hit by wind?

1. establish inside - outside relationship
2. determine wind- and leeward side
3. angle between wind direction and facade



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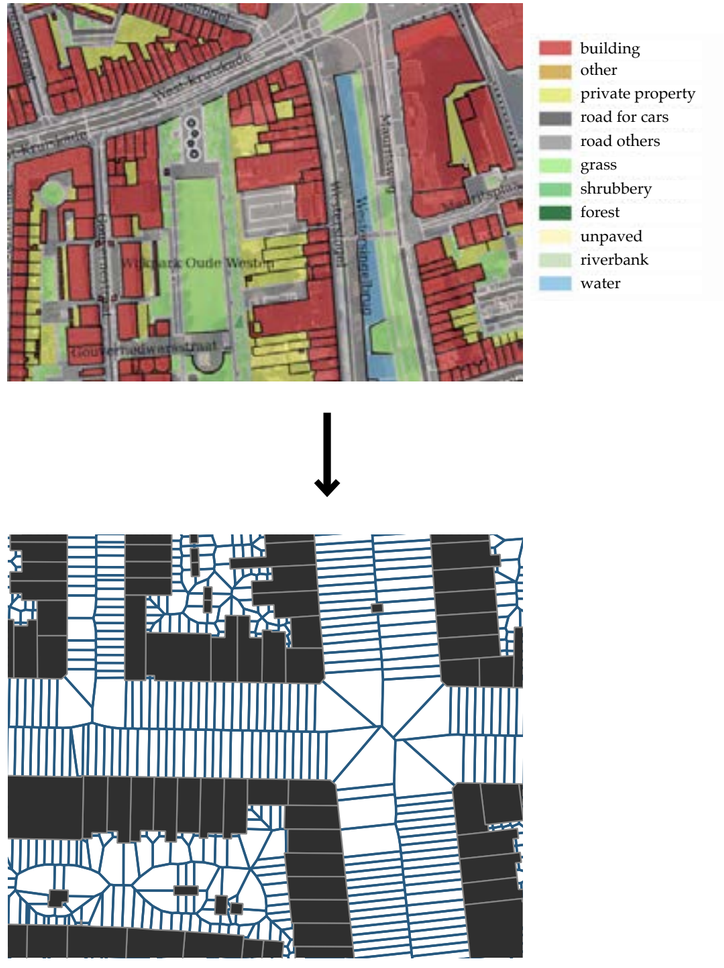
terrain roughness

- Dutch open data BGT dataset (Basis Grootschalige Topografie)
- assign roughness value to each material



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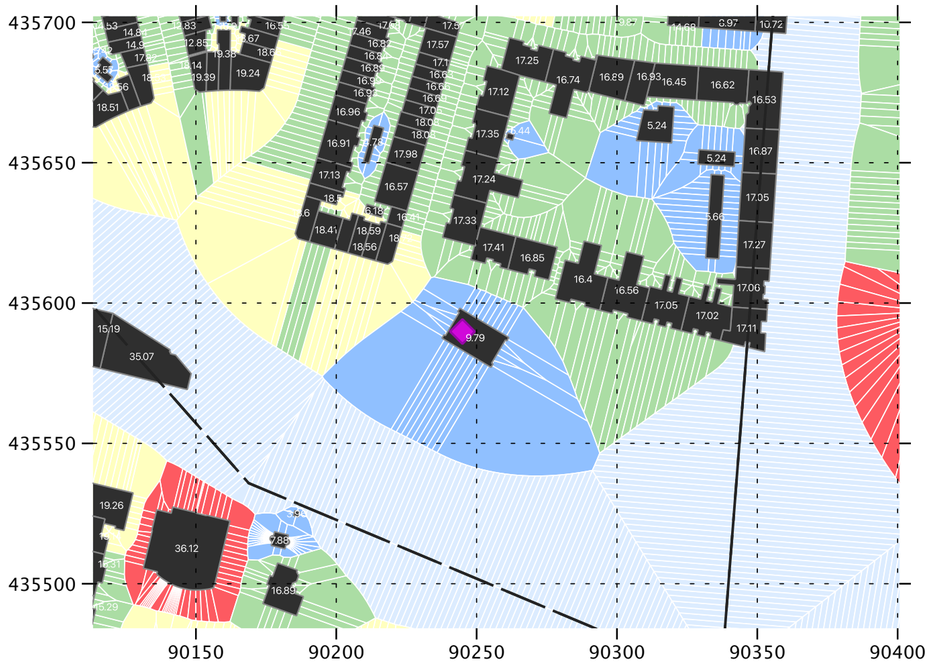

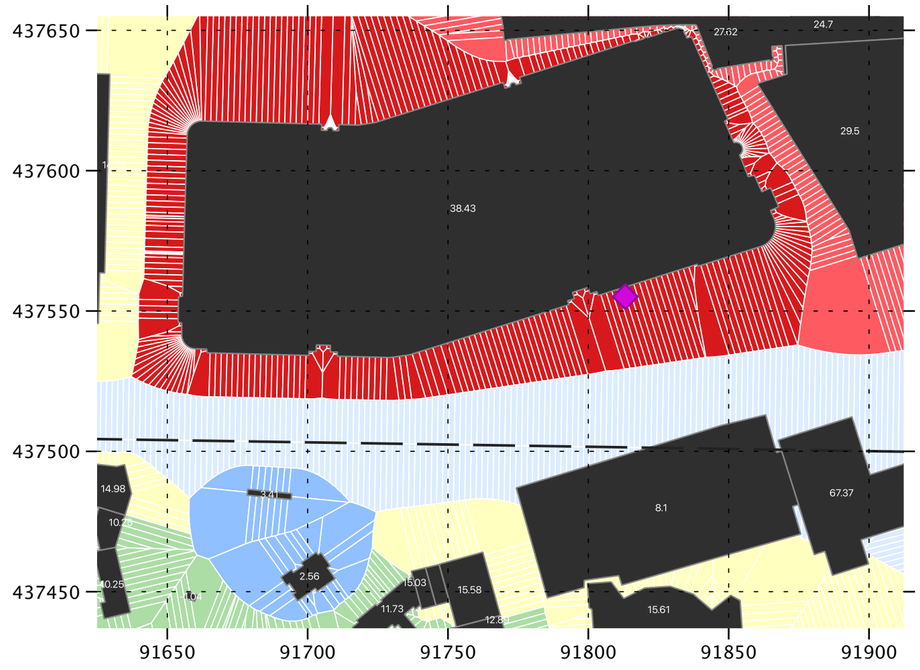

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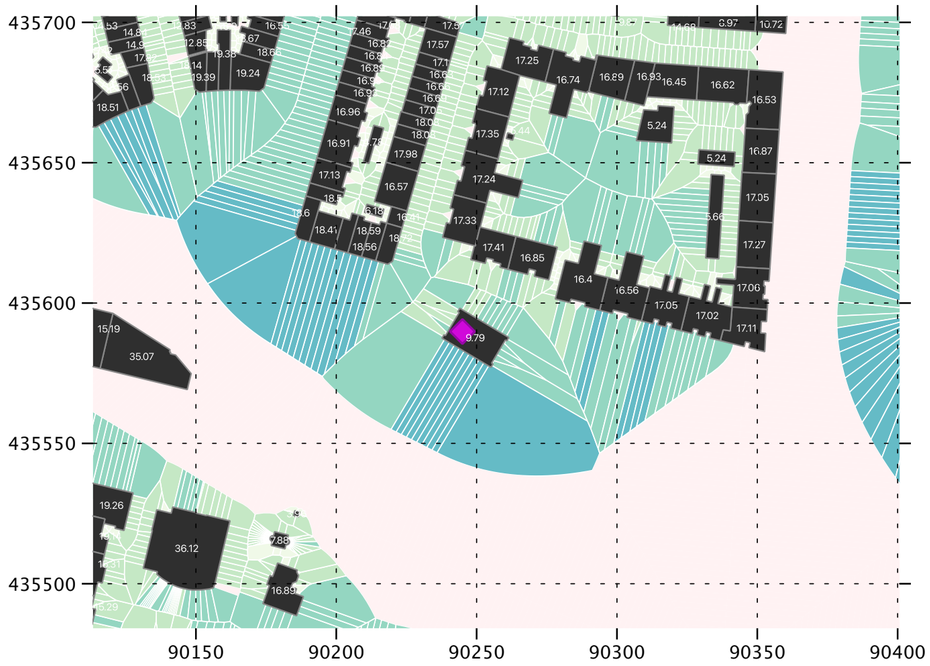

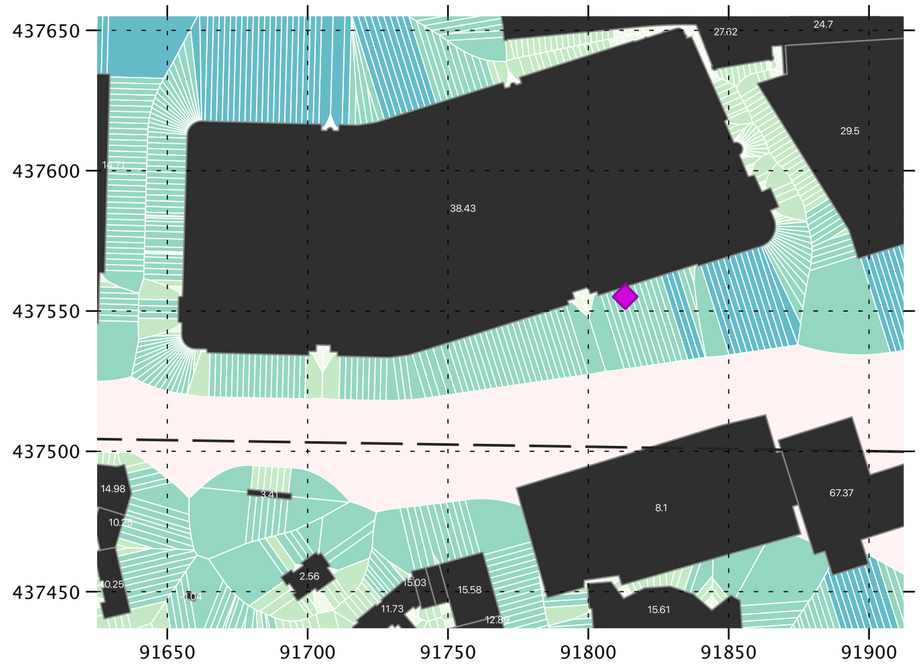

Street Width

- 3D BAG
- Neighborhood polygon
- Meteorological station

Widths [m]

- 1,0 - 3,2
- 3,2 - 10,0
- 10,0 - 31,6
- 31,6 - 100,0
- 100,0 - 316,2
- 316,2 - 1000,0
- NaN

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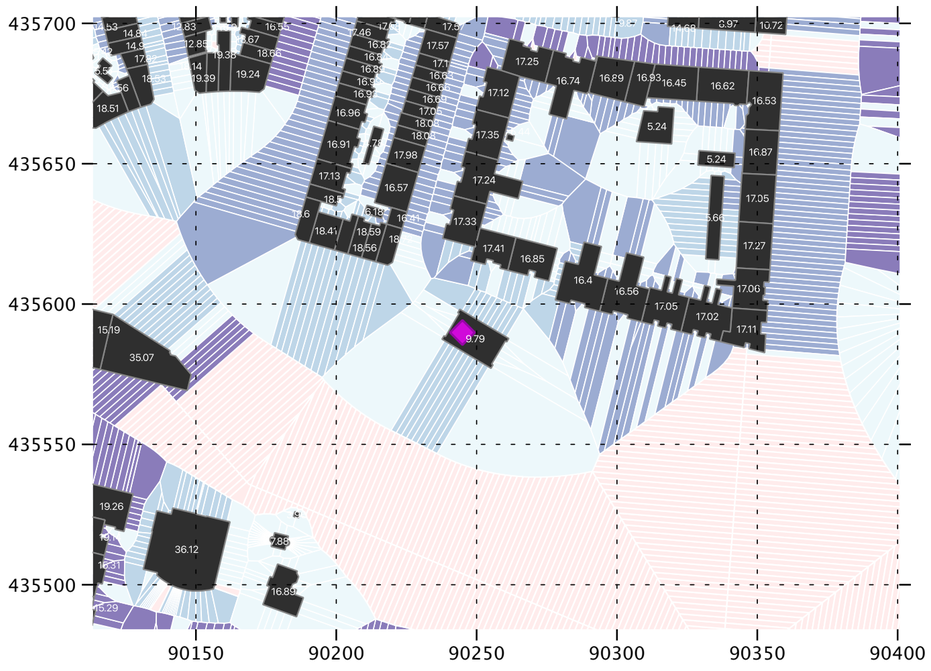
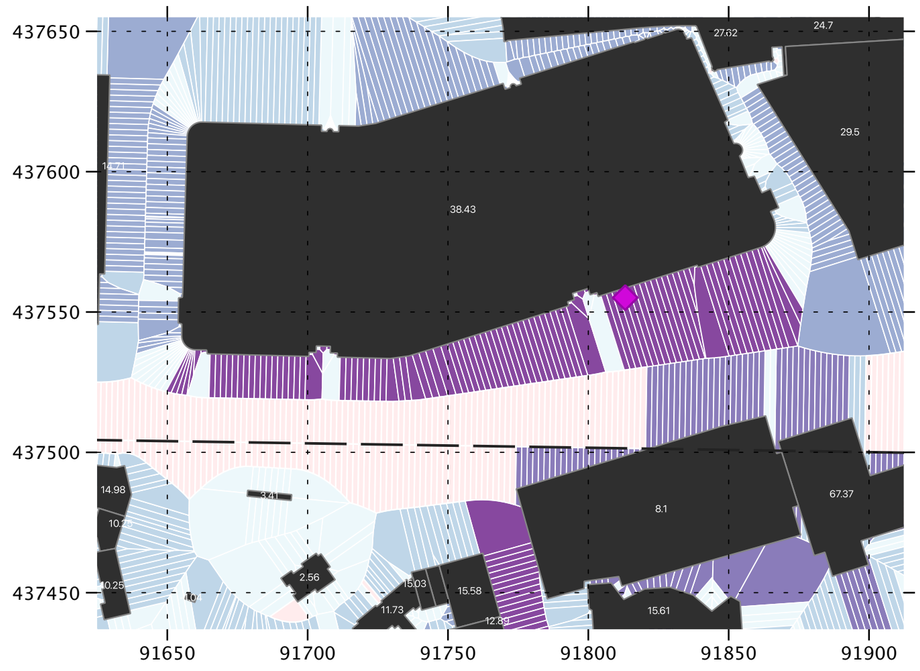


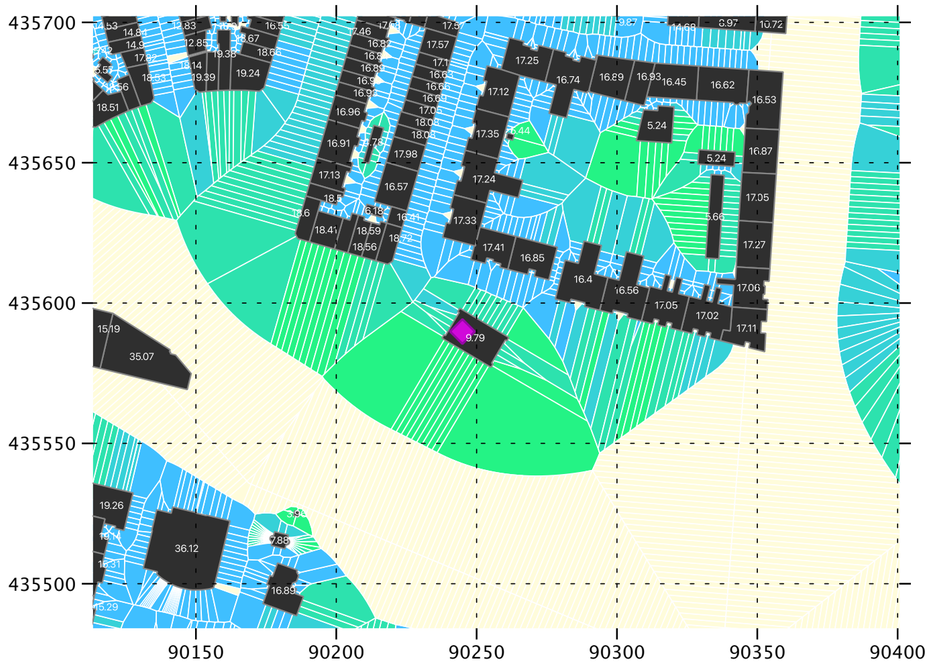


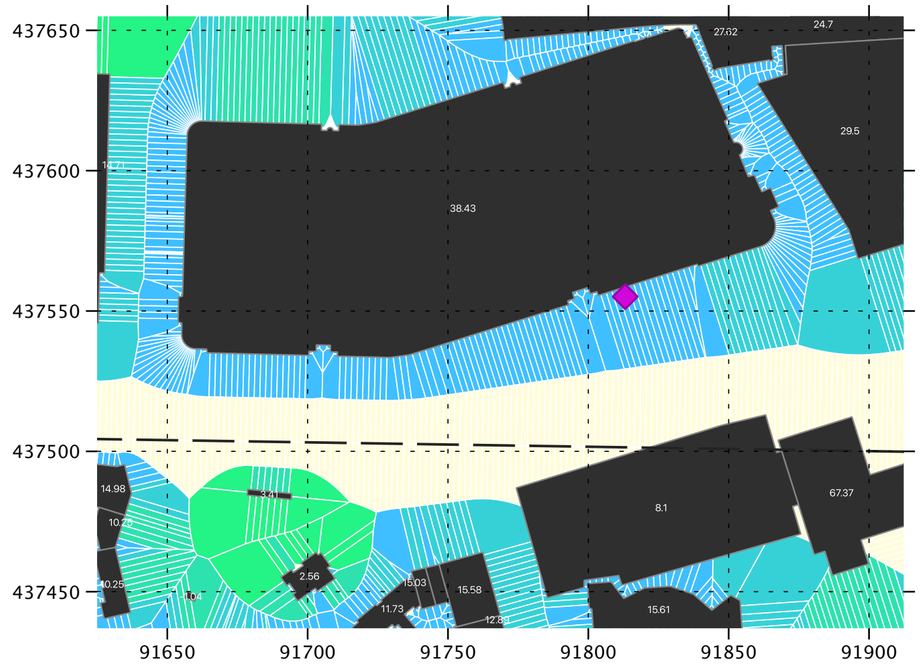
Facade Length

- 3D BAG
- Neighborhood polygon
- Meteorological station

Length [m]

- 0 - 20
- 20 - 50
- 50 - 100
- 100 - 150
- 150 - 350
- 350 - 800
- NaN





Urban Canyon H/W

- 3D BAG
- Neighborhood polygon
- Meteorological station

Height to Width ratio [H/W]

- 0 - 0,4
- 0,4 - 0,7
- 0,7 - 1,2
- 1,2 - 149,6
- NaN

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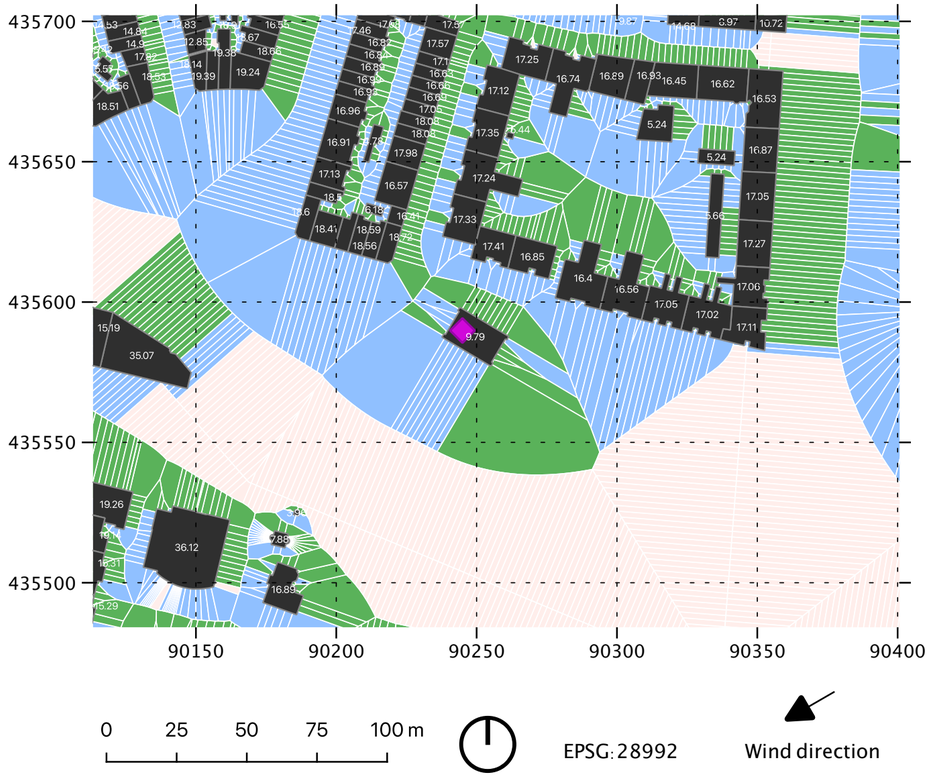

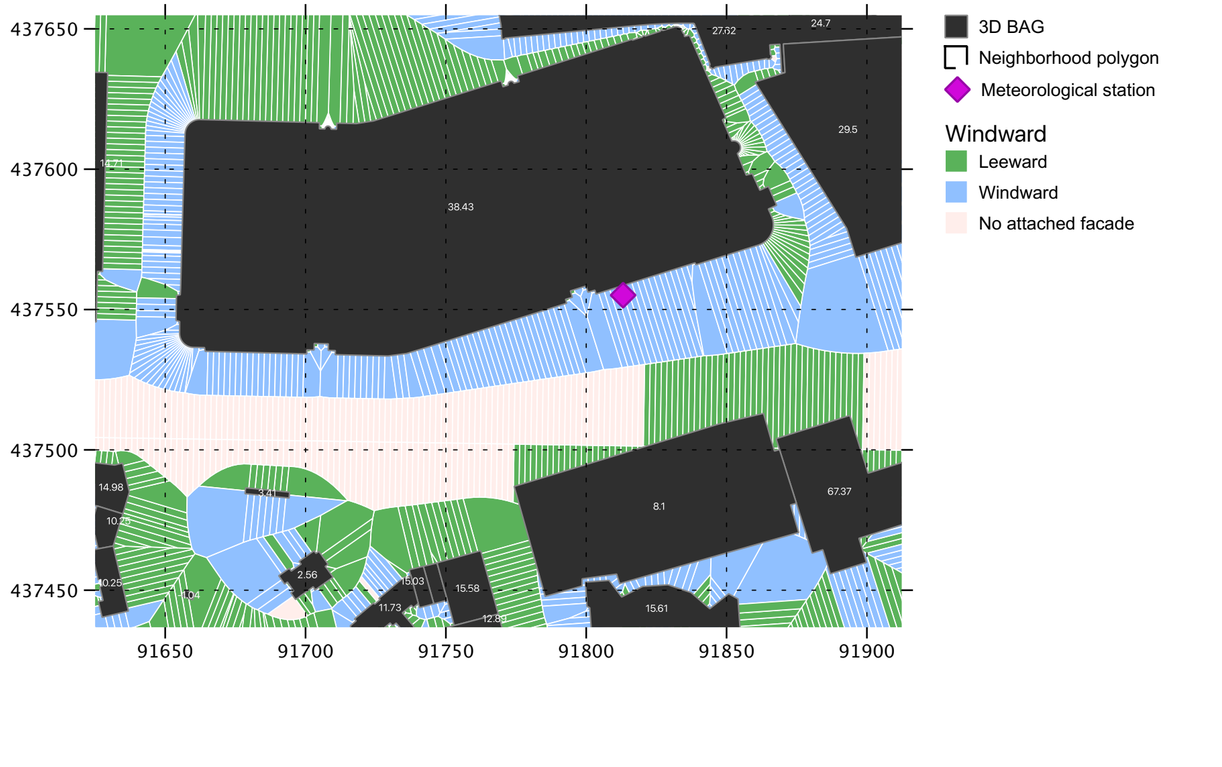

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by Wessel de Jongh
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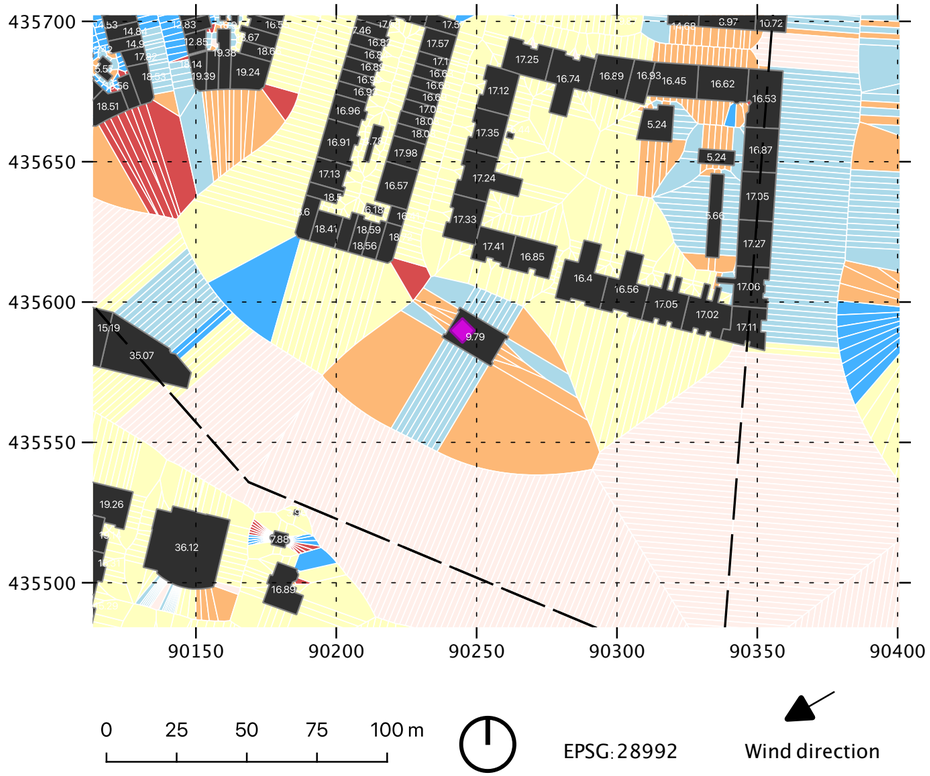

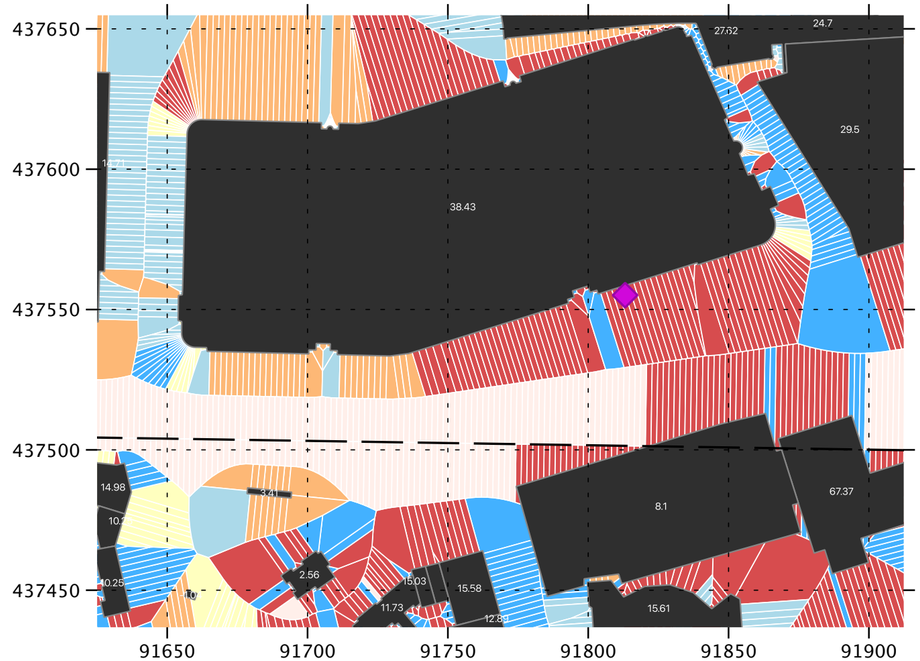

Angle of Attack [wd=240]

- 3D BAG
- Neighborhood polygon
- Meteorological station

Angle of Attack

- 0 - 18
- 18 - 36
- 36 - 54
- 54 - 72
- 72 - 90
- No attached facade

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Roughness Length

- 3D BAG
- Neighborhood polygon
- Meteorological station

Roughness length [z0]

- 0,0002
- 0,005
- 0,03
- 0,1
- 0,25
- 0,5
- 1
- NaN

wind velocity potential

- Point-based score system to indicate potential increase in wind velocity
- threshold values from research:

parameter/score	5	4	3	2	1
building height (H)	$H >= 23$	$15.7 <= H < 23$	$13.34 <= H < 15.7$	$10.3 <= H < 13.34$	$H < 10.3$
H / W ratio (UC)	$HW <= 0.05$	$0.05 < HW <= 0.4$	$0.4 < HW <= 0.65$	$0.65 < HW <= 1$	$HW > 1$
W / L ratio (WL)			$WL <= 0.07$	$0.07 < WL <= 0.56$	$WL > 0.56$
L / H ratio (LH)			$LH <= 1.42$	$1.42 < LH <= 3.69$	$LH > 3.69$
angle of attack (AoA)	$AoA < 18$	$18 <= AoA < 36$	$36 <= AoA < 54$	$54 <= AoA < 72$	$72 <= AoA <= 90$
windward				*Yes*	*No*
roughness length (zo)	0.0002	0.005	0.03	0.1	z0 <= 0.25

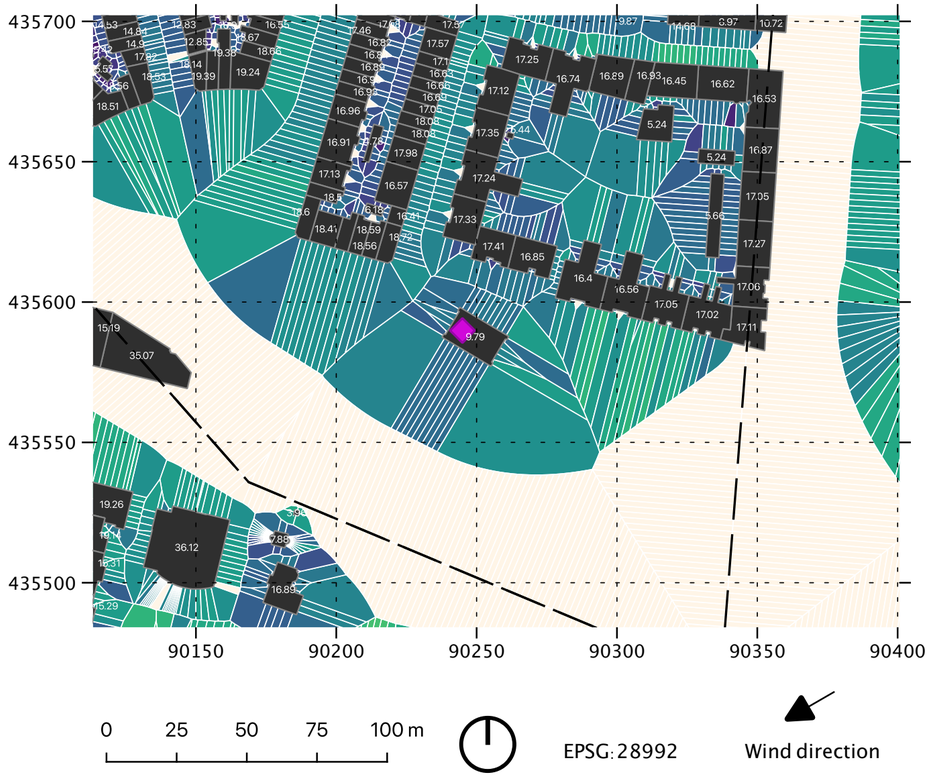
wind velocity potential

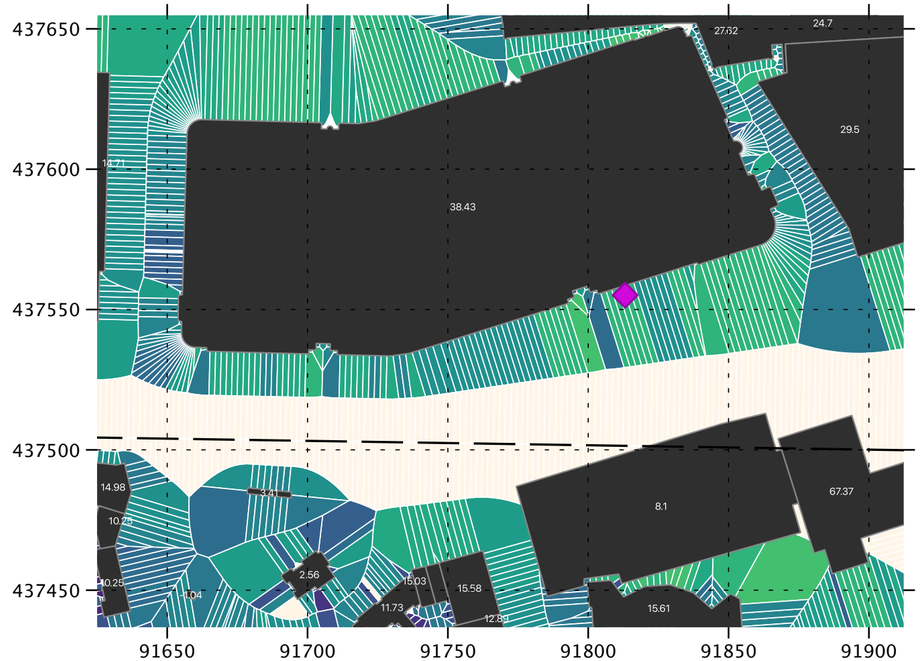
- Point-based score system to indicate potential increase in wind velocity
- threshold values from research:

parameter/score	5	4	3	2	1
building height (H)	$H >= 23$	$15.7 <= H < 23$	$13.34 <= H < 15.7$	$10.3 <= H < 13.34$	$H < 10.3$
H / W ratio (UC)	$HW <= 0.05$	$0.05 < HW <= 0.4$	$0.4 < HW <= 0.65$	$0.65 < HW <= 1$	$HW > 1$
W / L ratio (WL)			$WL <= 0.07$	$0.07 < WL <= 0.56$	$WL > 0.56$
L / H ratio (LH)			$LH <= 1.42$	$1.42 < LH <= 3.69$	$LH > 3.69$
angle of attack (AoA)	$AoA < 18$	$18 <= AoA < 36$	$36 <= AoA < 54$	$54 <= AoA < 72$	$72 <= AoA <= 90$
windward				*Yes*	*No*
roughness length (zo)	0.0002	0.005	0.03	0.1	$z0 <= 0.25$

parameter	**value**	**score**
canyon height [m]	39	5
H/W ratio	1,34	1
W/L ratio	0,14	2
L/H ratio	5,4	1
z_0 [m]	0,005	4
windward 210°	yes	2
angle of attack 210°	13,8°	5
total		20

wind velocity potential





Score [wd=240]

- 3D BAG
- Neighborhood polygon
- Meteorological station

Score

- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- No score

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by Wessel de Jongh
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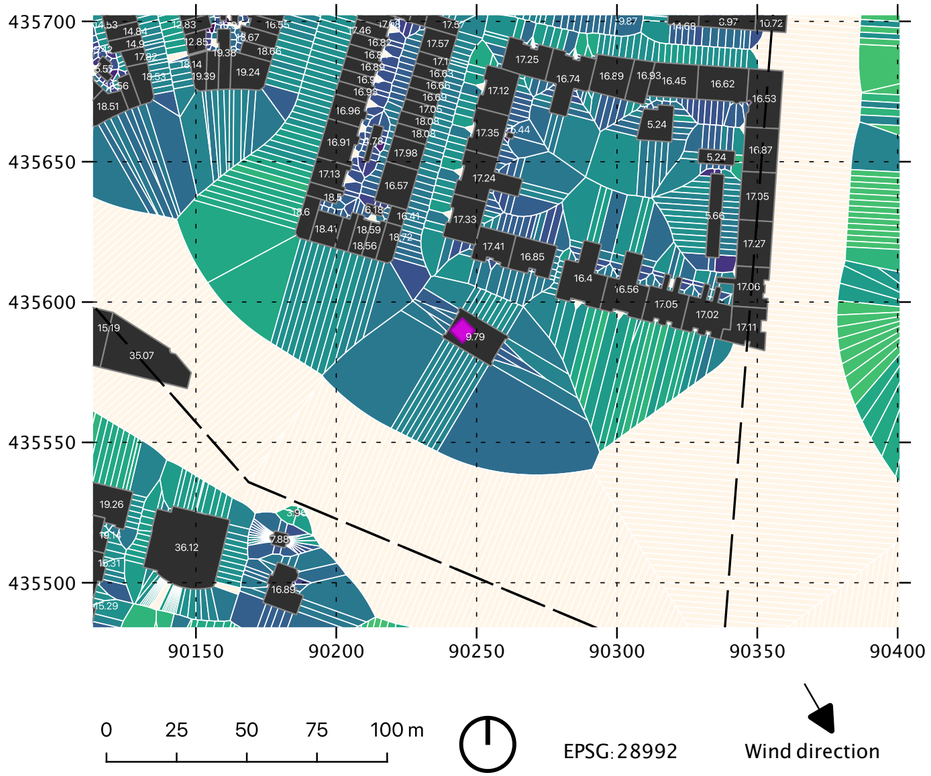
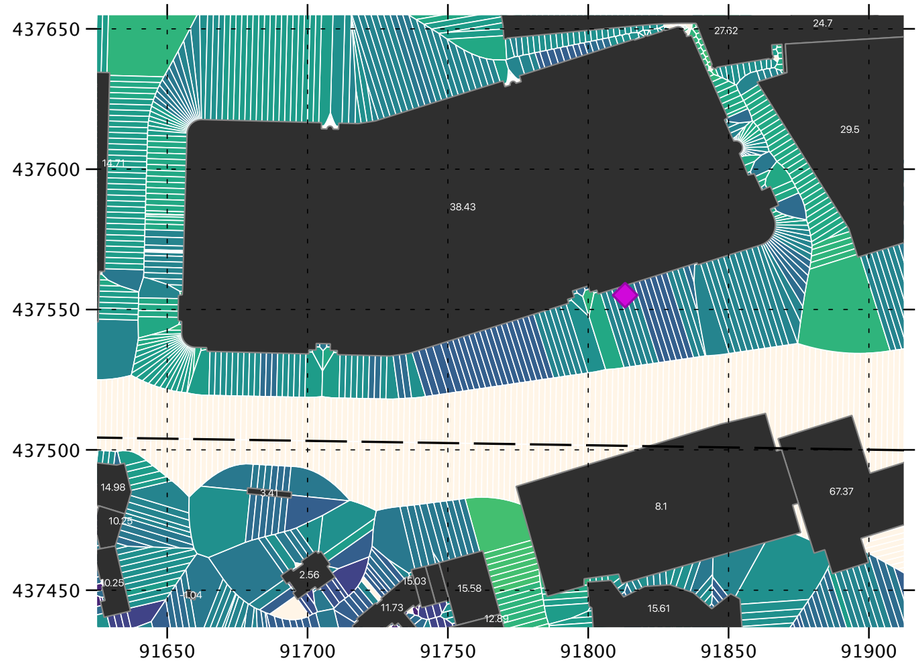
wind velocity potential





Score [wd=150]

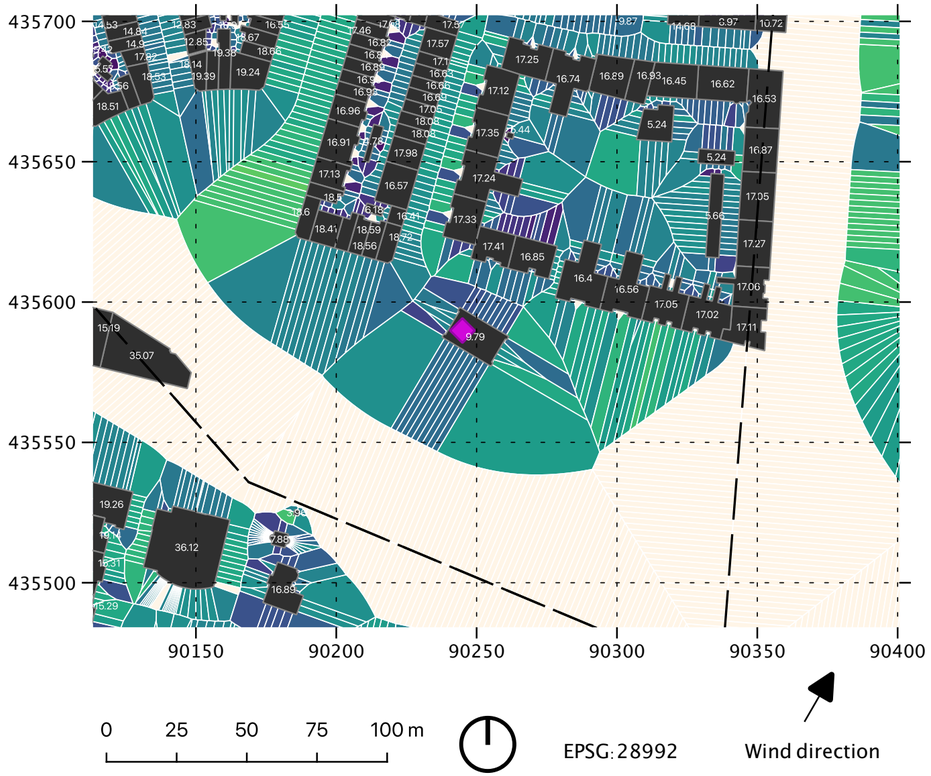
- 3D BAG
- Neighborhood polygon
- Meteorological station

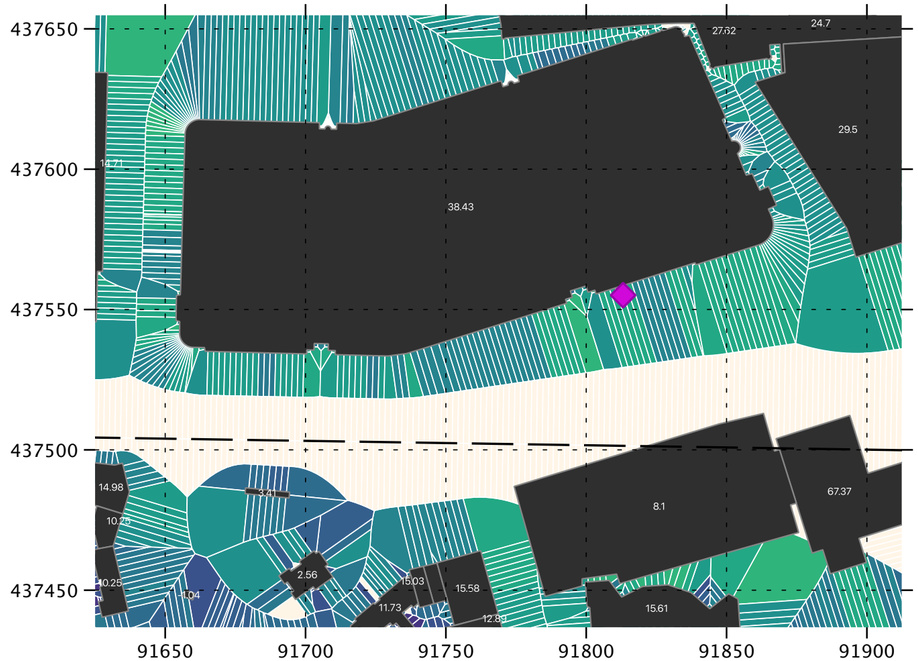
Score

- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- No score

Urban Morphological Analysis for Wind Potential
by Wessel de Jongh
MSc Geomatics, TU Delft

wind velocity potential





Score [wd=30]

- 3D BAG
- Neighborhood polygon
- Meteorological station

Score

- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- No score

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score validation

Do higher scores relate to an increase in potential wind velocity?

score validation

Do higher scores relate to an increase in potential wind velocity?

What is the average wind velocity at the **urban weather station** when the **reference station** measures:

i. wind velocity 1 ± 0.1 m/s
ii. wind direction 0 ± 5 degrees

score validation

Do higher scores relate to an increase in potential wind velocity?

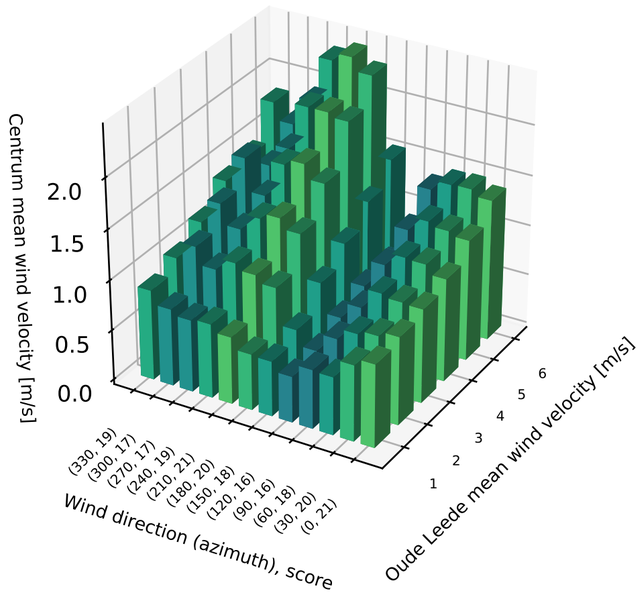
What is the average wind velocity at the **urban weather station** when the **reference station** measures:

i. wind velocity 1 ± 0.1 m/s
ii. wind direction 0 ± 5 degrees

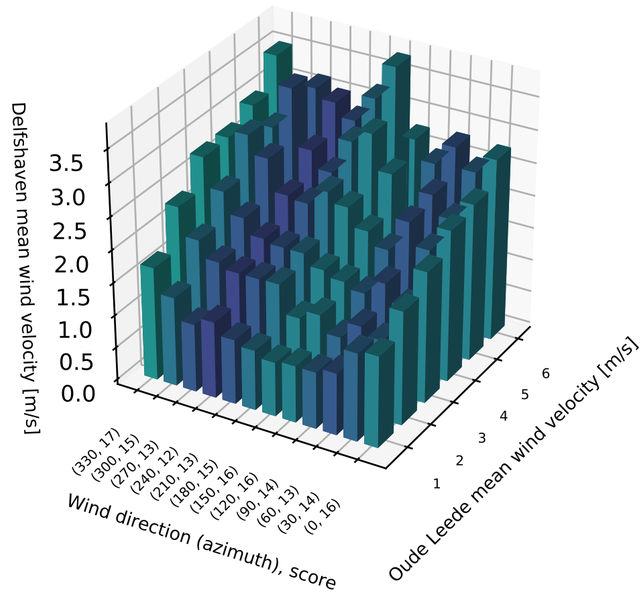
station	reference station	query WD ref	score	station mean WS 1 ±0.1	ref mean WS 1 ±0.1	# measurements 1	station mean WS 2 ±0.1	ref mean WS 2 ±0.1	# measurements 2	station mean WS 3 ±0.1	ref mean WS 3 ±0.1	# measurements 3	station mean WS 4 ±0.1	ref mean WS 4 ±0.1	# measurements 4	station mean WS 5 ±0.1	ref mean WS 5 ±0.1	# measurements 5	station mean WS 6 ±0.1	ref mean WS 6 ±0.1	# measurements 6
centrum	oude leede	0	21	0.83	1.00	144.0	0.88	2.00	145.0	0.94	3.01	122.0	1.03	4.00	93.0	1.21	5.01	47.0	1.40	5.97	3.0
centrum	oude leede	30	20	0.76	1.00	241.0	0.83	2.00	182.0	0.95	3.00	134.0	1.12	3.99	107.0	1.25	4.99	66.0	1.47	6.00	14.0
centrum	oude leede	60	18	0.58	1.00	203.0	0.79	2.00	259.0	0.98	3.00	197.0	1.13	4.00	102.0	1.29	4.99	66.0	1.46	6.00	14.0
centrum	oude leede	90	16	0.59	1.00	100.0	0.68	2.00	68.0	0.78	3.00	93.0	1.00	4.00	78.0	1.15	5.00	21.0	1.36	6.00	9.0
centrum	oude leede	120	16	0.46	1.00	174.0	0.50	1.99	135.0	0.62	3.00	100.0	0.73	4.00	85.0	0.76	5.01	52.0	0.85	5.99	38.0
centrum	oude leede	150	18	0.55	0.99	107.0	0.65	2.00	119.0	0.91	3.00	147.0	1.10	4.00	135.0	1.32	5.00	106.0	1.55	6.00	51.0
centrum	oude leede	180	20	0.56	1.00	289.0	1.01	1.99	218.0	1.34	3.00	273.0	1.64	4.00	279.0	2.06	5.00	226.0	2.33	6.00	202.0
centrum	oude leede	210	21	0.67	1.00	322.0	1.08	1.99	244.0	1.44	3.00	251.0	1.78	4.00	273.0	2.10	5.00	310.0	2.46	6.01	172.0
centrum	oude leede	240	19	0.74	1.00	138.0	1.14	2.00	318.0	1.38	3.00	345.0	1.72	4.00	228.0	2.10	5.00	192.0	2.38	6.00	145.0
centrum	oude leede	270	17	0.72	1.00	104.0	1.02	2.00	88.0	1.22	3.00	87.0	1.36	4.00	75.0	1.64	5.00	50.0	1.93	6.02	18.0
centrum	oude leede	300	17	0.77	1.01	76.0	1.19	2.01	105.0	1.42	3.00	99.0	1.68	3.99	51.0	1.42	4.96	15.0	1.65	6.01	7.0
centrum	oude leede	330	19	0.90	1.00	114.0	1.02	2.00	153.0	1.18	3.00	177.0	1.40	4.00	97.0	1.47	5.01	58.0	1.82	6.00	13.0

score validation

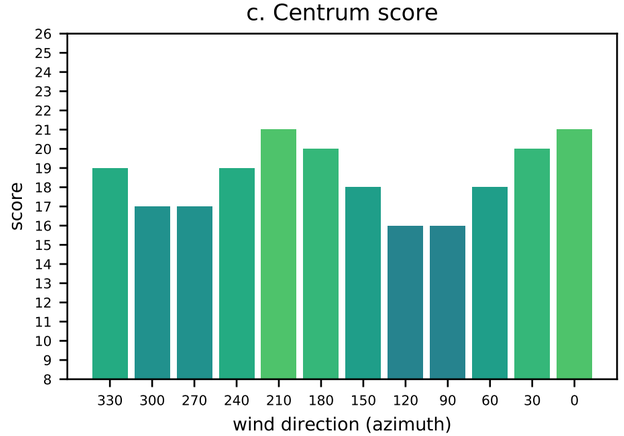
a. Centrum station 3D Bar plot



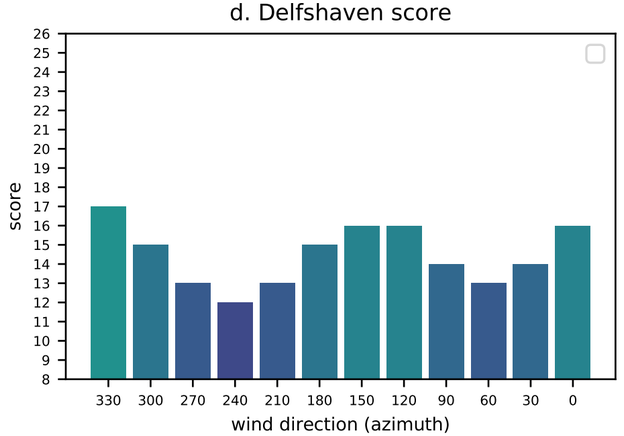
b. Delfshaven station 3D Bar plot



c. Centrum score



d. Delfshaven score



score validation

- wind measurements are stochastic in the short-term
- too complex to just take the mean of all measurements
    i. time of day; night / day
    ii. seasonal
    iii. temperature
    iv. relative humidity
    v. pressure
- the time window of the urban stations do not overlap; direct comparison in time is therefore not possible between urban stations

Urban Morphological Analysis
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MSc Geomatics, TU Delft

Can we use urban morphology to automatically calculate potential increase in wind velocity?

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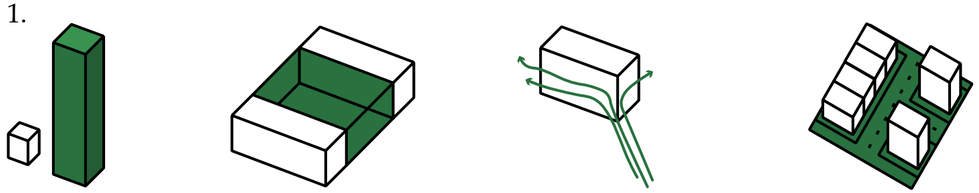
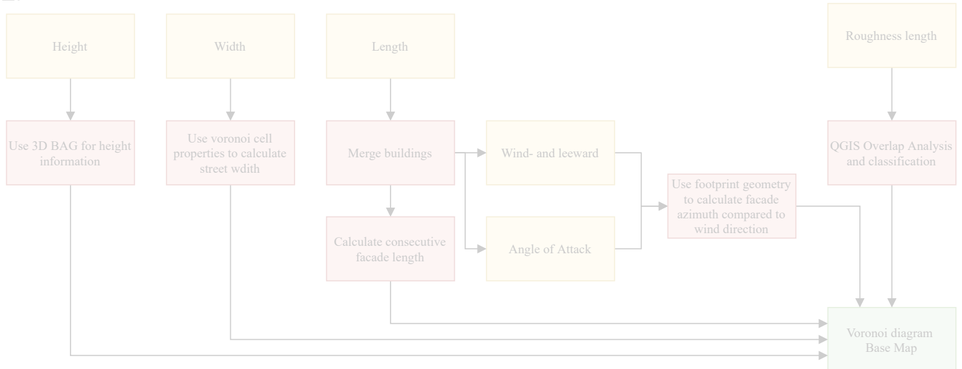
conclusion

1. How do different morphological parameters relate to wind velocity?
2. How can we develop a methodology to compute multiple morphological parameters?
3. Is this method suitable for identifying potentially increased wind velocity situations?
4. Can we use meteorological stations to validate the methodology?

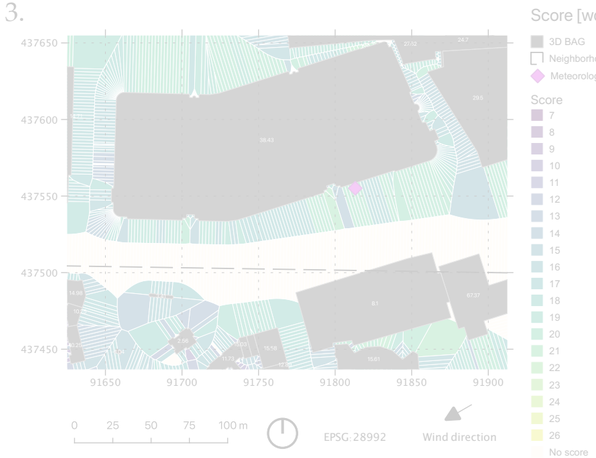
1.



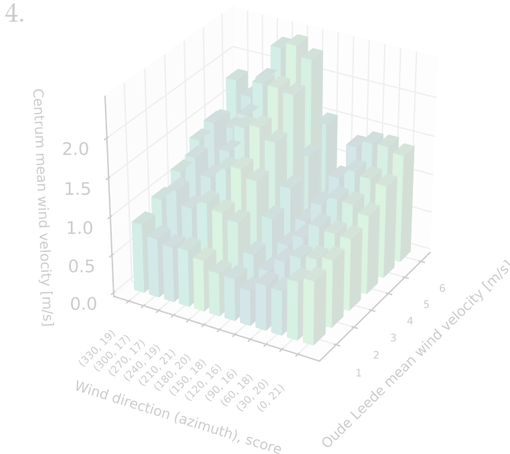
2.



3.



4.



Urban Morphological Analysis for Wind Potential
by Wessel de Jongh
MSc Geomatics, TU Delft

conclusion

1. How do different morphological parameters relate to wind velocity?
2. How can we develop a methodology to compute multiple morphological parameters?
3. Is this method suitable for identifying potentially increased wind velocity situations?
4. Can we use meteorological stations to validate the methodology?

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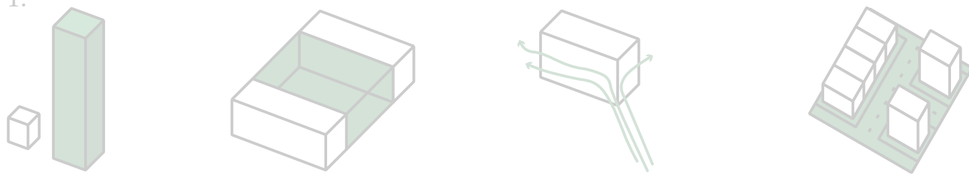

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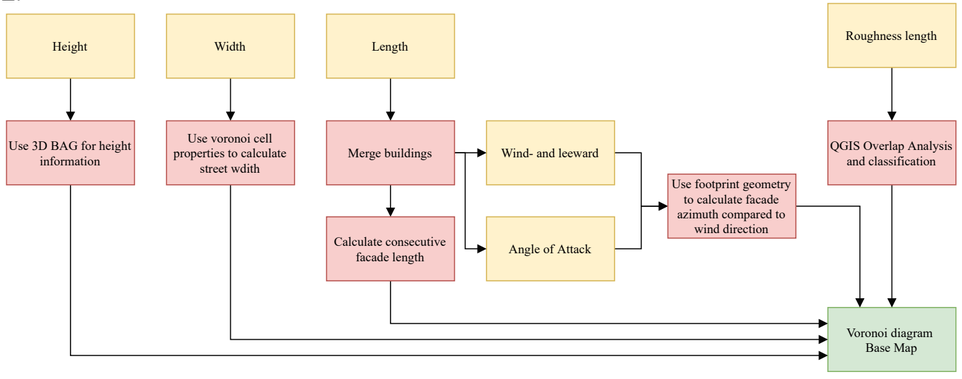

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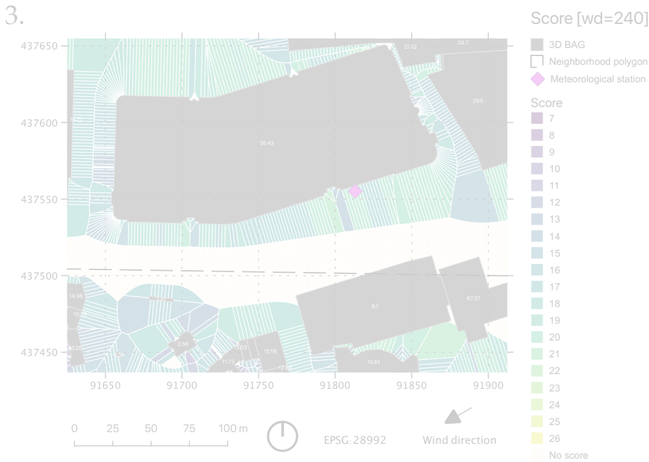

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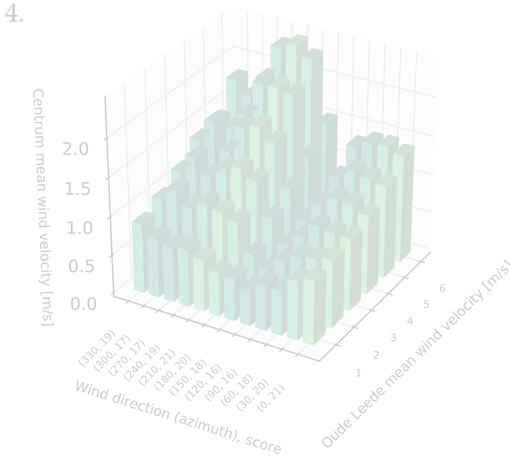

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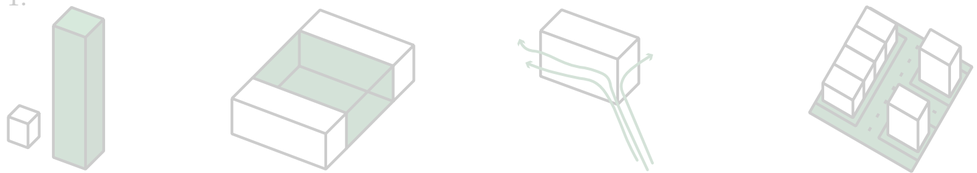

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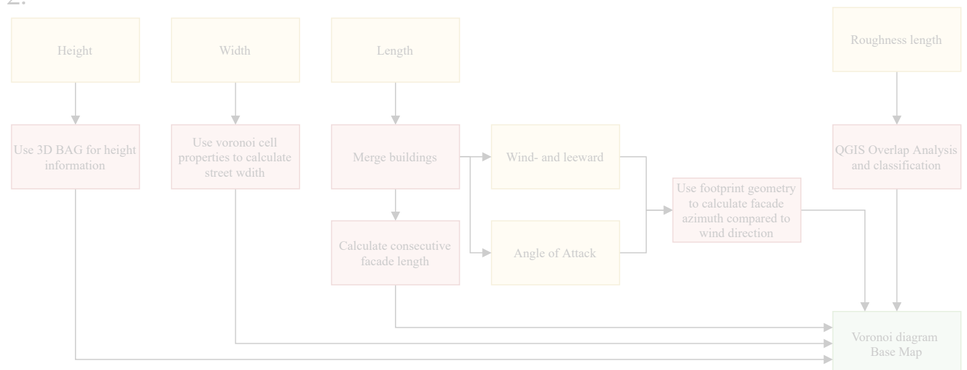

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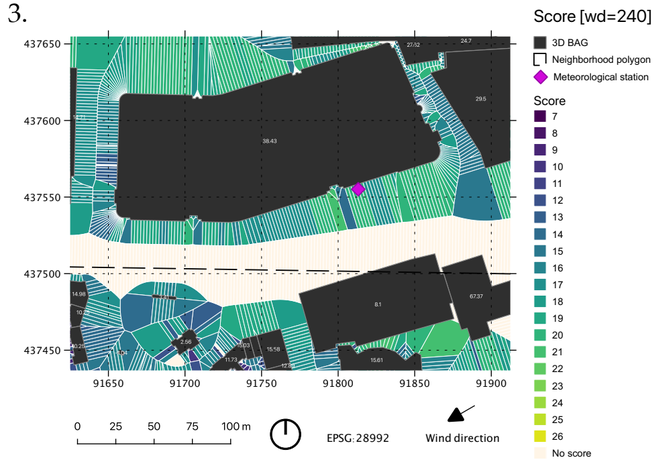

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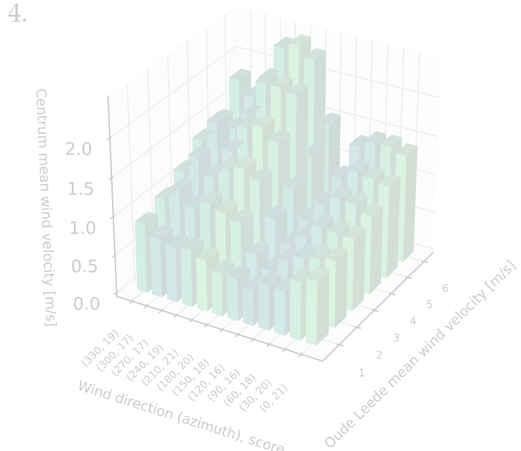

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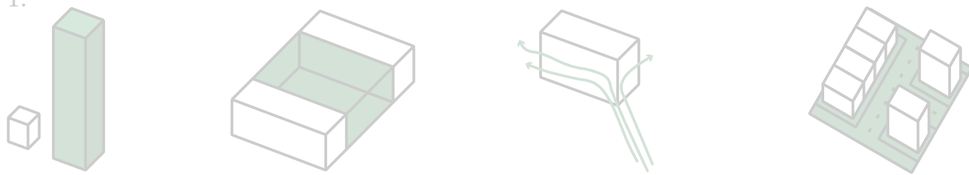

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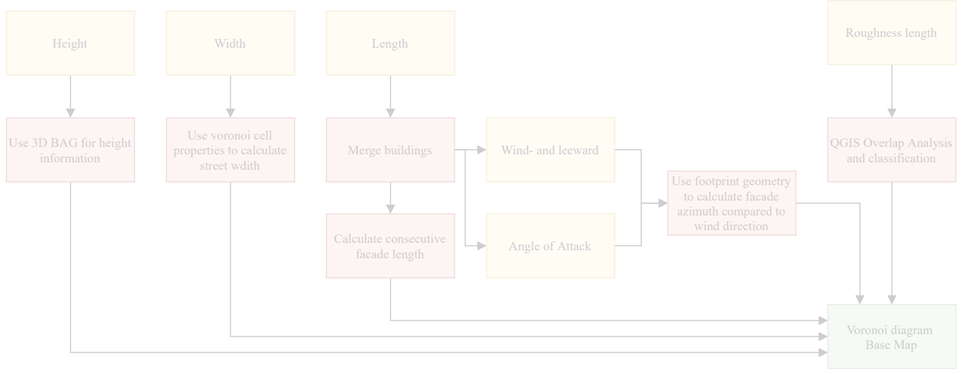

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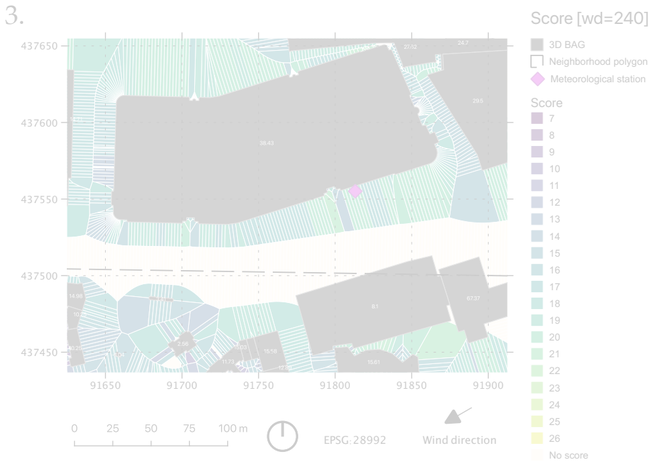

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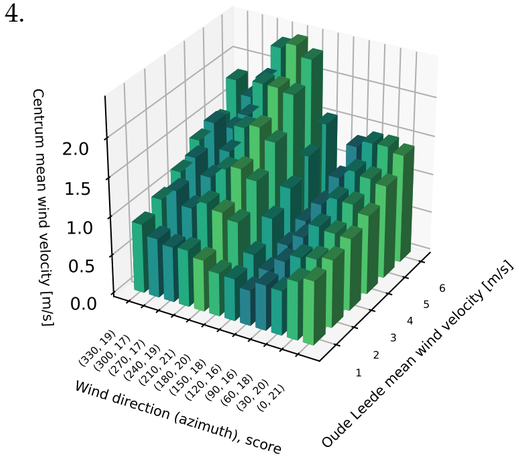

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discussion

- other morphological parameters
- calculating the urban morphological parameters
- morphological parameters ⇸ potential increase in wind velocity
- scoring system

future research

- morphological parameters ⟷ potential increase in wind velocity
- Computational Fluid Dynamics simulations
- other fields of research

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Second supervisor:	Balàzs Dukai
Co-reader:	Daniela Maiullari
Exam delegate:	Ype Cuperus

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wrap up

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wrap up

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thank you

bibliography

Arnold, S., Apsimon, H., Barlow, J., Belcher, S. E., Bell, M., Boddy, J., Britter, R., Cheng, H., Clark, R., Colvile, R., Dimitroulopoulou, C., Dobre, A., Greally, B., Kaur, S., Knights, A., Lawton, T., Makepeace, A., Martin, D., Neophytou, M., and Walsh, P. (2004). Introduction to the dapple air pollution project. *The Science of the total environment*, 332:139–53.

Badach, J., Voordeckers, D., Nyka, L., and Van Acker, M. (2020). A framework for air quality management zones - useful gis-based tool for urban planning: Case studies in antwerp and gdańsk. *Building and Environment*, 174:106743.

Beranek, W. and Koten, H. V. (1979). *Beperken van windhinder om gebouwen, deel 1, Stichting Bouwresearch no. 65*. Kluwer Technische Boeken BV, Deventer.

Blocken, B. and Carmeliet, J. (2004). Pedestrian wind environment around buildings: Literature review and practical examples. *Journal of Thermal Environment and Building Science*, 28(2):107–159.

Carpentieri, M. and Robins, A. G. (2015). Influence of urban morphology on air flow over building arrays. *Journal of Wind Engineering and Industrial Aerodynamics*, 145:61–74.

Ceccarelli, G., de Jongh, W., Lánský, I., Li, J., Mastorakis, K., Teeuwisse, S., Peters, R., Sanchez, C. G., and Stoter, J. (2019). Bepalen luchtverontreiniging door verkeer met behulp van 3d-geo-informatie. *Geo-Info*, 16(4):34–39.

Chen, L., Hang, J., Sandberg, M., Claesson, L., Sabatino, S. D., and Wigo, H. (2017). The impacts of building height variations and building packing densities on flow adjustment and city breathability in idealized urban models. *Building and Environment*, 118:344–361.

Claus, J., Coceal, O., Thomas, T. G., Branford, S., Belcher, S., and Castro, I. P. (2011). Wind-direction effects on urban-type flows. *Boundary-Layer Meteorol*, (142):265–287.

Fleischmann, M., Feliciotti, A., Romice, O., and Porta, S. (2020). Morphological tessellation as a way of partitioning space: Improving consistency in urban morphology at the plot scale. *Computers, Environment and Urban Systems*, 80:101441.

He, B.-J., Ding, L., and Prasad, D. (2019). Enhancing urban ventilation performance through the development of precinct ventilation zones: A case study based on the greater sydney, australia. *Sustainable Cities and Society*, 47:101472.

Janssen, W., Blocken, B., and van Hooff, T. (2013). Pedestrian wind comfort around buildings: Comparison of wind comfort criteria based on whole-flow field data for a compex case study. *Building and Environment*, 59:547–562.

Jiang, D., Jiang, W., Lui, H., and Sun, J. (2008). Systematic influence of different building spacing, height and layout on mean wind and turbulent characteristics within and over urban building arrays. *Wind and Structures*, 11(4):275–289.

Kubota, T., Miura, M., Tominaga, Y., and Mochida, A. (2008). Wind tunnel tests on the relationship between building density and pedestrian-level wind velocity: Development of guidelines for realizing acceptable wind environment in residential neighborhoods. *Building and Environment*, 43(10):1699–1708.

Oke, T. R. (1988). Street design and urban canopy layer climate. *Energy and Buildings*, 11:103–113.

Park, S.-J., Kim, J.-J., Choi, W., Kim, E.-R., Song, C.-K., and Pardyjak, E. R. (2019). Flow characteristics around step-up street canyons with various building aspect ratios. *Boundary-Layer Meteorology*, 174:411–431.

Razak, A. A., Hagishima, A., Ikegaya, N., and Tanimoto, J. (2013). Analysis of airflow over building arrays for assessment of urban wind environment. *Building and Environment*, 59:56–65.

Rijksoverheid (2021).

Roberts, S. A., Hall, G. B., and Boots, B. (2005). Street centreline generation with an approximated area voronoi diagram. In *Developments in Spatial Data Handling*, pages 435–446, Berlin, Heidelberg. Springer Berlin Heidelberg.

Samsonov, T. E., Konstantinov, P. I., and Varentsov, M. I. (2015). Object-oriented approach to urban canyon analysis and its applications in meteorological modeling. *Urban Climate*, 13:122–139.

Soulhac, L., Garbero, V., Salizzoni, P., Mejean, P., and Perkins, R. (2009). Flow and dispersion in street intersections. *Atmospheric Environment*, 43(18):2981–2996.

Soulhac, L., Perkins, R., and Salizzoni, P. (2008). Flow in a street canyon for any external wind direction. *Boundary-Layer Meteorology*, 126:365–388.

Tsang, C., Kwok, K., and Hitchcock, P. (2012). Wind tunnel study of pedestrian level wind environment around tall buildings: Effects of building dimensions, separation and podium. *Building and Environment*, 49:167–181.

Wieringa, J. (1992). Updating the davenport roughness classification. *Journal of Wind Engineering and Industrial Aerodynamics*, 41(1):357–368.