Generating an Interdisciplinary Planning Framework to Support Climate Resilient Places

Understanding the **#UrbanClimate** Rules!

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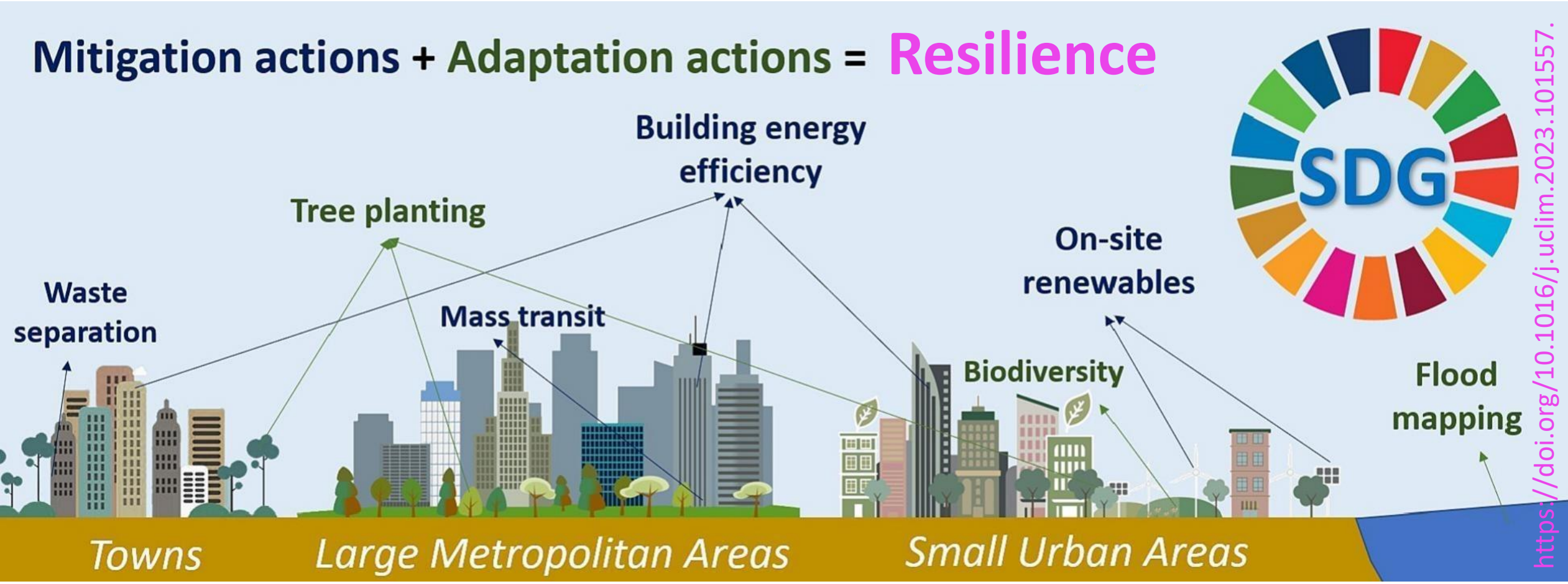
★ RESILIENCE & THE IMPORTANCE OF THE URBAN CLIMATE RULES



Resilience is essential in both mitigation and adaptation to environmental and climate challenges:

- In mitigation, it involves developing systems (like renewable energy sources) that reduce sensitivity to climate change and maintain functionality.
- In adaptation, resilience is about enhancing the ability of communities and systems to withstand and recover from the effects of climate change, such as extreme weather or sea-level rise.

Essentially, resilience ensures robustness and flexibility in facing environmental changes

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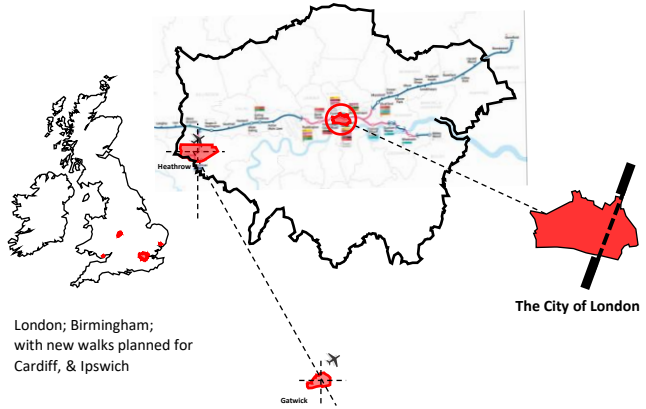
An Urban Climate Walking Tour an instructional technique for linking together diverse aspects of urban sustainability: The City of London



London; Birmingham;
with new walks planned for
Cardiff, & Ipswich

NEXT WALK

The City of London urban climate walking tour (established 2014) is a research led walk, which leads us through a series of urban streets and public spaces. Here, we explore some of the consequences of building and urban form on the background climate; alongside disseminating current thinking around the various urban climate effects.

The walk provides a unique perspective of our built environments by demonstrating the far-reaching and dynamic links between built-form, climate, energy and health and wellbeing across various scales. It offers an opportunity for us to discuss the quality of the spaces in terms of their physical form, materiality and social implications, alongside their influence on green infrastructure and thermal comfort, critical components of healthy resilient cities.

Designed to teach the principles of urban climatology from an interdisciplinary perspective to a wide range of built environment practitioners, the walk is suitable for anyone with an interest in the climates of cities.

The walk takes between 2 and 3 hours giving plenty of time for discussion; the walk can be done under all weather conditions… In fact the harsher the conditions the more dramatic the walk …. Sensible clothing and footwear are essential – this is not a walk in the park!

Meeting Point ❶ **The Martha Smith Memorial Water Fountain - 39 Finsbury Square, London, England, EC2A**
Finishing Point ⓫ 120 Fenchurch Street Roof Garden (if open)

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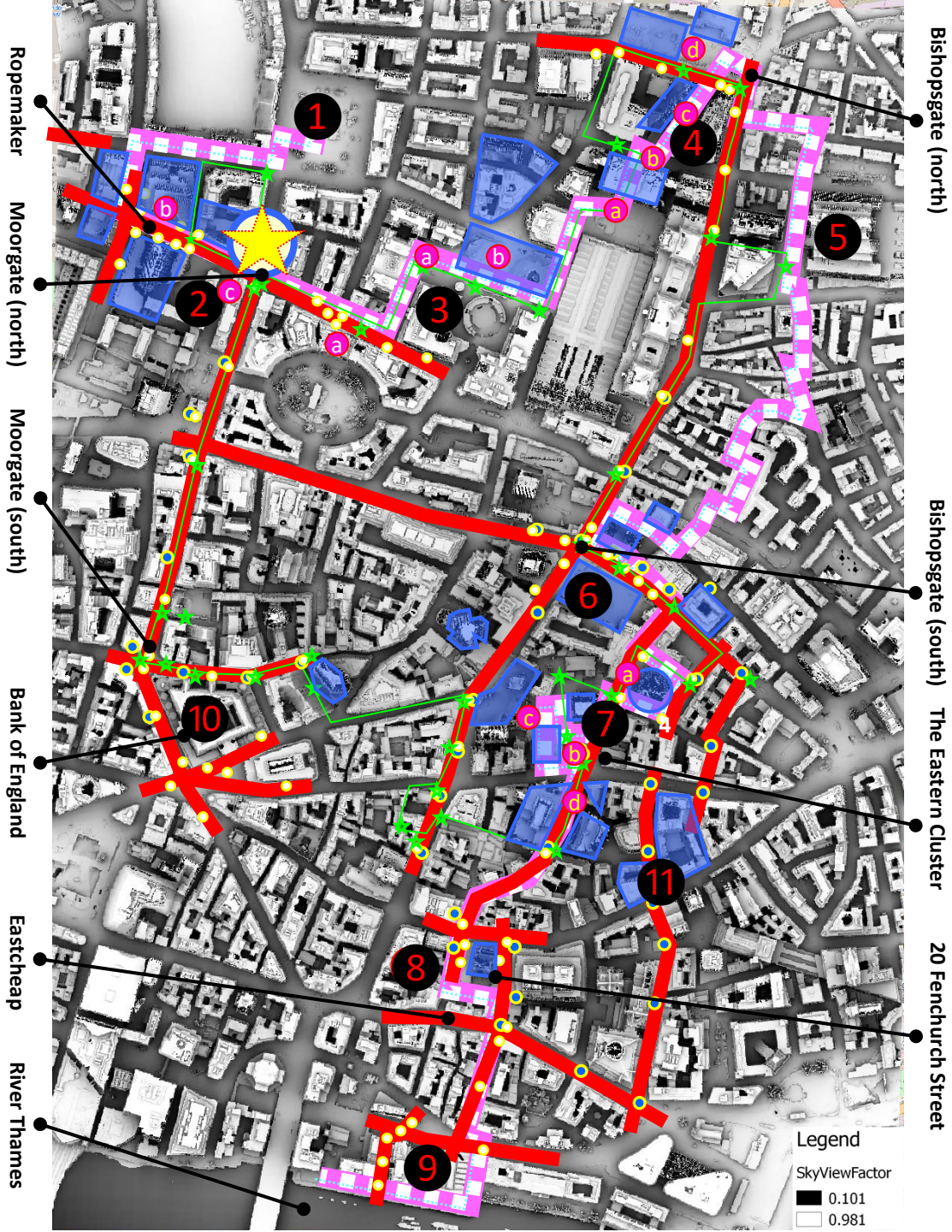

KEY

- An open site
- Intersection
- Street
- BLOCK
- Single Tower
- 2 or more Towers
- Cluster of Towers
- Symmetrical
- Square
- Orientation Ø E/W
- Orientation Ø N/S
- South facing
- Vegetation Good health
- Vegetation Poor health
- Water
- Daytime Function
- Nighttime Function

- Tall Buildings
- Urban Climate Walking Route
- Background Site
- Microclimate & Black Carbon Measurements PART 3
- ❶ Areas of Interest
- Microclimate & Nitrogen Dioxide (NO_2) Measurements PART 1 & 2

		Ø	LAYOUT	SYMMETRY	BUILT FORM	H/W	LCZ	GREEN / BLUE INFRASTRUCTURE	FUNCTION (day/night)
❶		Finsbury Square	○		★	□	<0.5	5	☌☌	○
❷	b	Ropemaker Place	◗	⎯		||	9	1	♈	○ ☾
❷	c	Upper Moorgate	✚	⎯	★	≡	1	2		○
❷	a	Eldon Place	◗	⎯		≡≡	2	2		○
❸	a	Finsbury Avenue Sq.	○	□		≡≡	1	2	☌	○
❸	b	5 Broadgate	⇊	□		≡≡≡	1	1	♈	○
❹	a	Exchange House	⇊	□		≡≡	1	2	☌💧	○
❹	b	Broadgate Tower	⇊	□		|	2	1	♈	○
❹	c	Worship Street	◗	⎯	★	|	3	1		
❹	d	Principle place	○	□		|	4	1	☌	☾
❺		Bishops Square (Spitalfields)	⬲	⎯		≡	1	2	☌☌💧	○
❻		110 & 100 Bishopsgate	◗	✚		||	7	2		○ ☾
❼	a	30 St Marys Axe	□			|||	3	1	☌	○
❼	b	St Helens Square	□			|||	8	1	☌	○
❼	c	Undershaft	□			|||	8	1		○
❼	d	Lime Street	□			|||	8	1		○
❽		20 Fenchurch Street	⇊	⎯		|	5	2	☌♈	○
❾		Thames Path; London Bridge	⇊			○		G	💧	
❿		Bank | Lower Moorgate	□	✚			1	2		○

★URBAN CLIMATE WALKING TOUR

The urban climate walk serves 3 distinct purposes

1) Disseminate complex interdisciplinary urban science in a digestible way
2) Data collection
3) Provide a network activity

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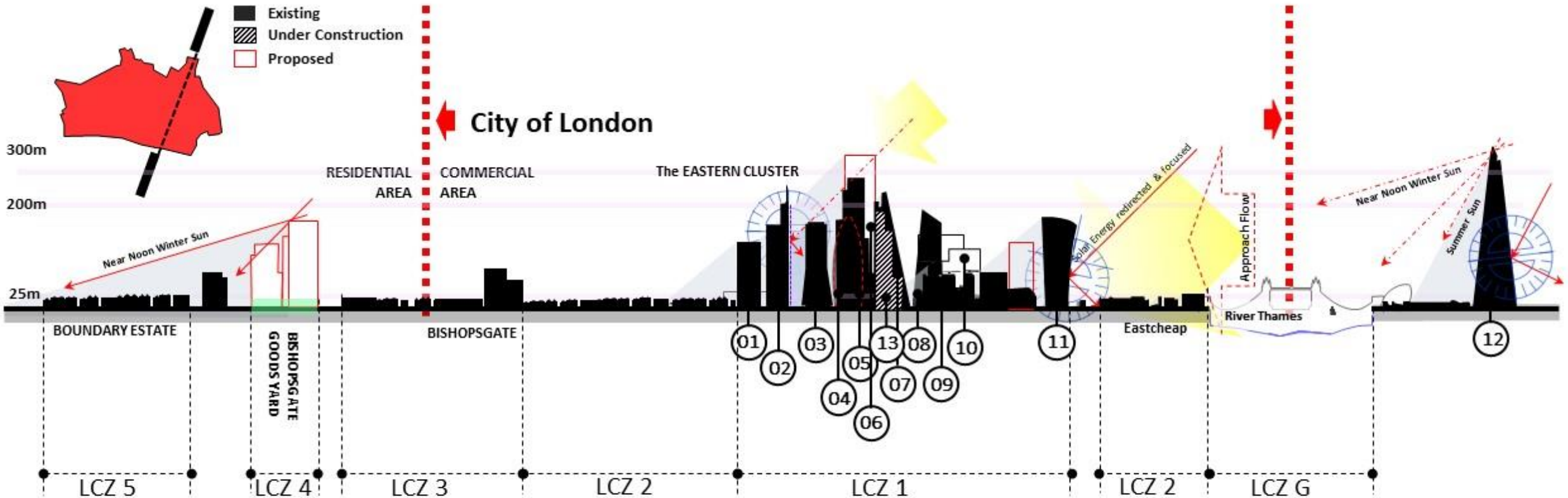
★BASED ON THE PRINCIPLES OF URBAN CLIMATE



01] 150 Bishopsgate (149m) The Heron Plaza
02] 110 Bishopsgate (230m) Heron Tower
03] 100 Bishopsgate (172m)
04] 30 St Marys Axe *(behind)* (180m) aka Gherkin
05] 22 Bishopsgate (278m) former Pinnacle development
06] No.1 Undershaft *(behind)* (295m)
07] 122 Leadenhall Street (224m) aka the Cheese Grater
08] 52-54 Lime St *(behind)* (192m) The Scalpel
09] 1 Lime St (95m) Lloyds Building
10] 51 Lime St *(behind)* (125m) Willis Building
11] 20 Fenchurch Street (160m) aka Walkie talkie/scorchie
12] 32 London Bridge (310m) The Shard
13] 8 Bishopsgate Tower

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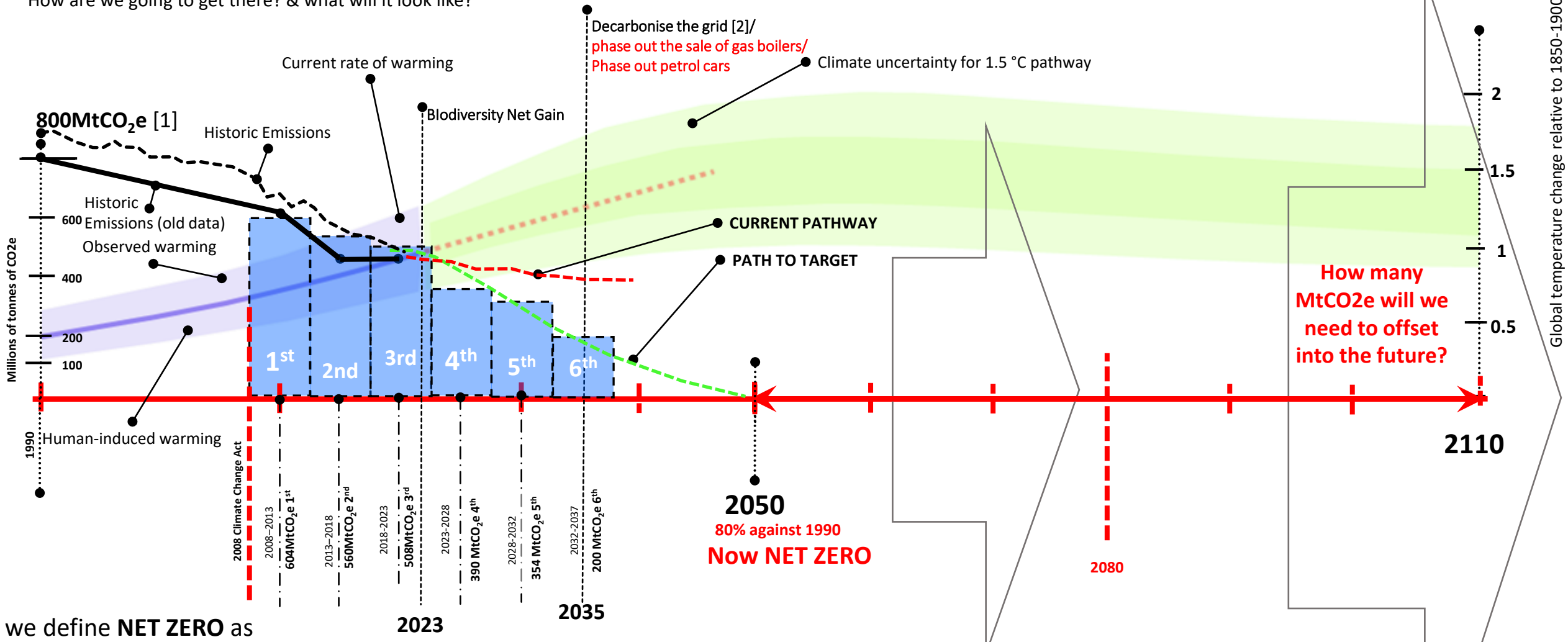
★ NET-ZERO CARBON TARGET (TIMELINE)

How are we going to get there? & what will it look like?



we define **NET ZERO** as

'achieving a balance between the carbon emitted into the atmosphere, and the carbon removed from it' (The Energy Saving Trust)

SEE - https://www.carbonbrief.org/ccc-uk-must-cut-emissions-78-by-2035-to-be-on-course-for-net-zero-goal/

Classwork – SEPT 2023

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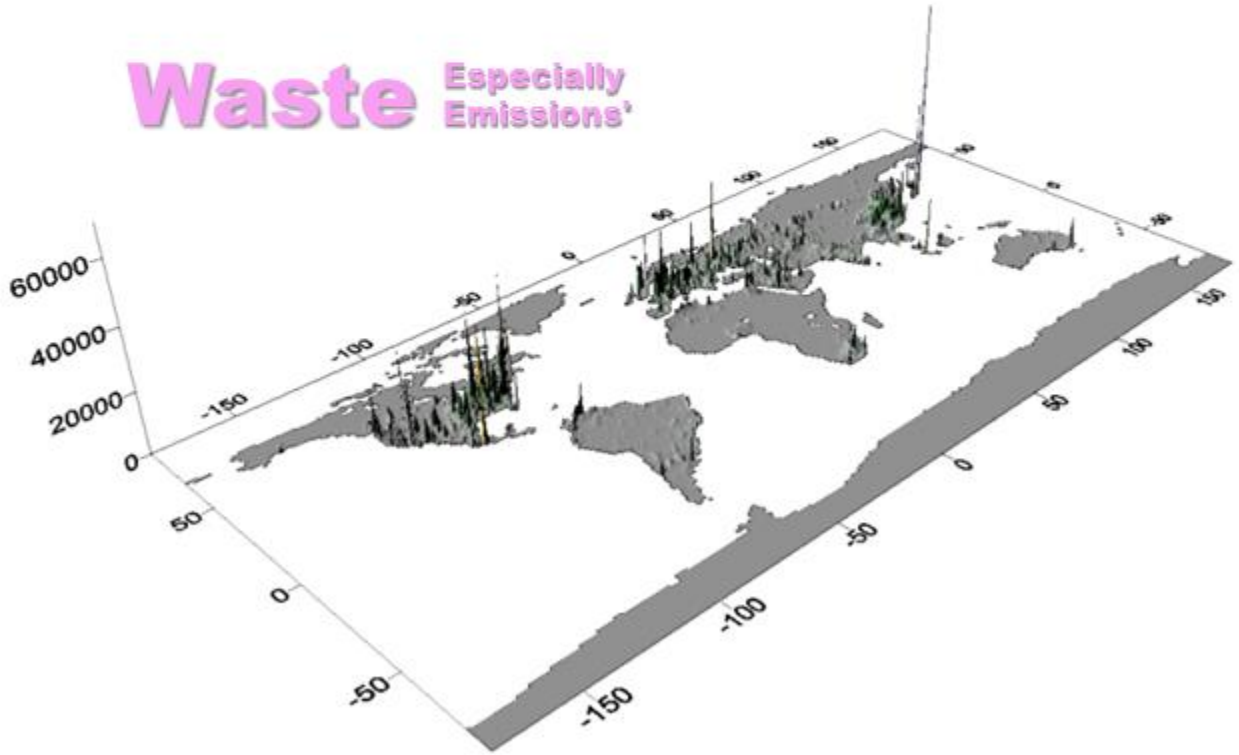
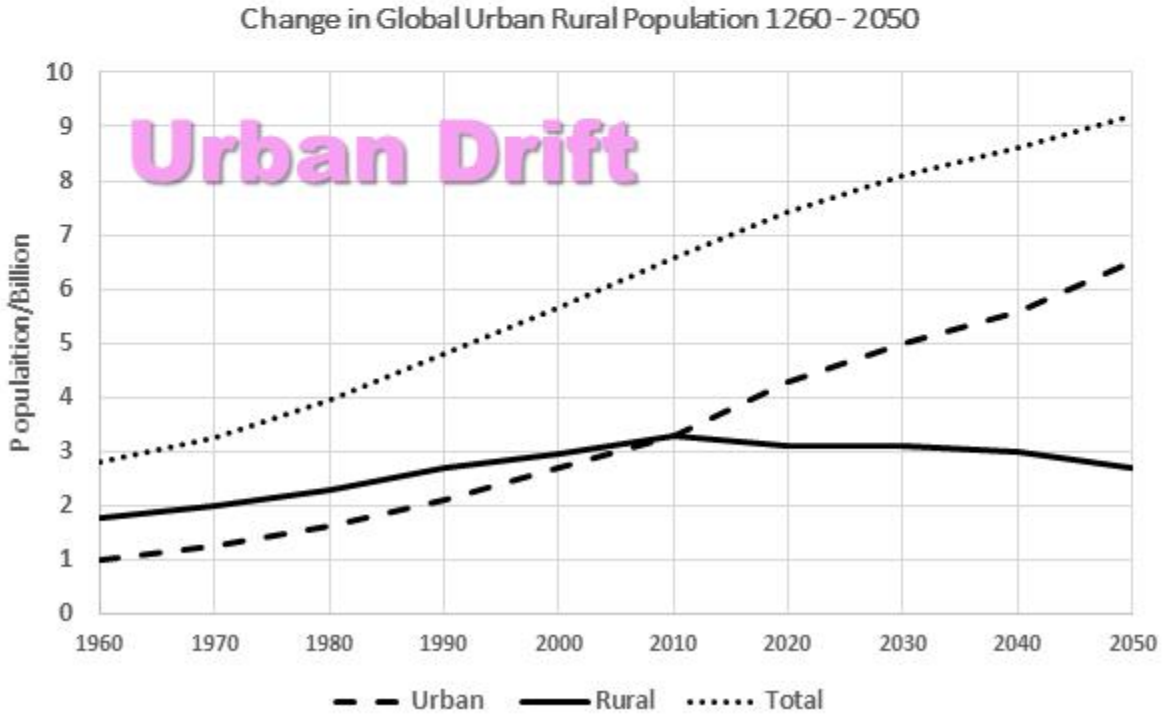
★ Challenges

- 50% of the Global Population live in urban environments (3.3 billion 2008) (Around 85% of total UK, population)
- 80% of the predicted 9.07 billion population by 2050
- Occupies <3% of ice-free land (Around 11% of total UK land mass)
- Producing 70% of global CO_2 e (in the UK, 49% of annual CO_2e are attributable to buildings) *1% of Global CO_2e
- Consume two thirds of global energy
- 50% of all energy is taken by buildings
- 80% of the UK's 2050 building stock is already in place
- 80% net-reduction CO_2e by 2050 (increased to 100% net-zero 2019)
- UK URBAN AIR TEMPERATURES to rise between 1.1 & 3.3 °C

(UN 2001, State of the World's Cities, www.unhabitat.org)





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★ where will all these buildings go?

Committee on Climate Change

Land use: Policies for a Net Zero UK

There is now a need to put in place clear, well-designed policies to ensure the UK's use of land contributes to the Net Zero emissions target.

- Agriculture, land use and peatlands accounted for **12%** (58 $MtCO_2e$) of all UK greenhouse gas emissions in 2017
- Our use of land **must change** to meet the UK's Net Zero target
- Actions set out by the CCC can reduce land-based emissions by **64%** by 2050
- While maintaining other **essential functions** of land, including food production and climate change adaptation
- This will also deliver **£4 billion** each year in environmental and other benefits

Actions must be taken now…

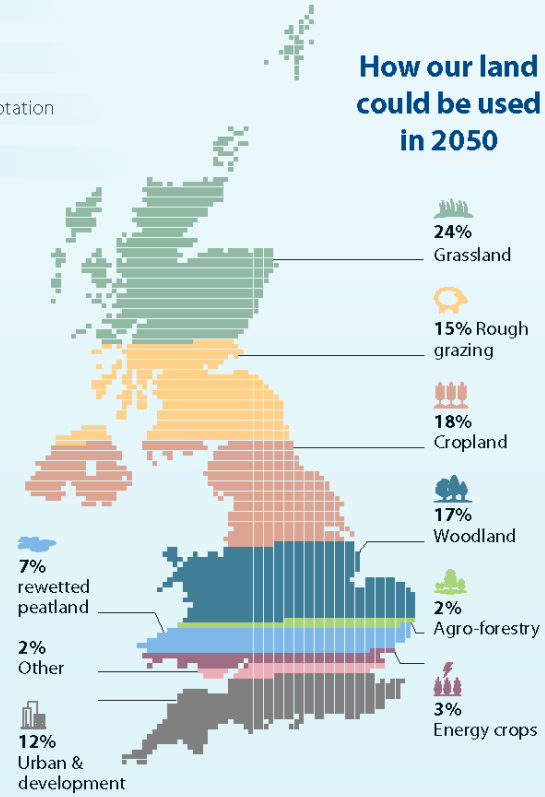
- Increase **low-carbon farming practices** for soils & livestock.
- Increase annual tree-planting to between **90-120 million** trees, equivalent to 30,000 hectares per year.
- Use **10%** of farmland for agro-forestry.
- Restore at least **55%** of peatland area by 2050.
- Increase the use of land for energy crops to **23,000 hectares** per year.

Behaviour change is also needed:

Reduce beef, lamb and dairy consumption by **20%** per capita by 2050.

Reduce food waste by **20%** by 2030.

How our land could be used in 2050



…to reduce agriculture and land use emissions…

Actions in these areas will lead to **43 $MtCO_2e$** of total annual emissions savings by 2050 compared with current practice continuing to 2050.

Emissions saving*	Forestry	Low-carbon farming practices	Diet change and food waste	Agro-forestry	Peatlands	2 $MtCO_2e$
	14 $MtCO_2e$	10 $MtCO_2e$	7 $MtCO_2e$	6 $MtCO_2e$	5 $MtCO_2e$	

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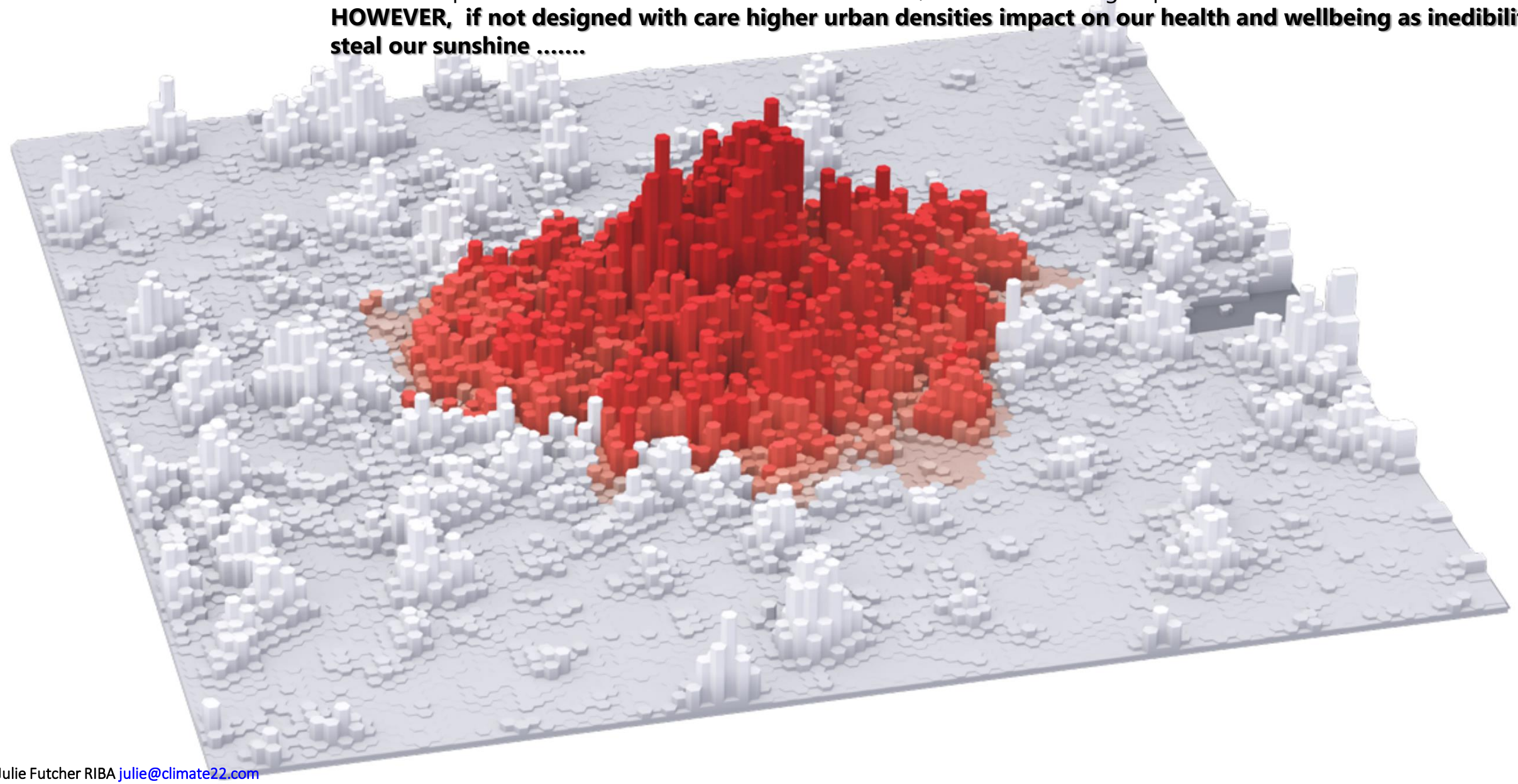
★ DENSITY

The relationship between built form, population density & sustainability is an interesting one Many believe that increasing urban density results in increased sustainability. whereby higher densities increase efficiencies …. i.e., more efficient public transport, walking and cycling, more integrated services and promote urban vitality & Lower densities and urban sprawl stretch all forms of urban infrastructure, while contributing to pollution and social exclusion.

HOWEVER, if not designed with care higher urban densities impact on our health and wellbeing as inedibility it steal our sunshine …….



https://urbanage.lsecities.net/data/ambient-density-london

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★ INCREASING URBAN DENSITY

Typically, this requires a good understanding of the interdependent relationships between building and urban **form and function, energy, climate**; and importantly how these interdependent net-energy relationships impact on **health and wellbeing**.

These affects include thermal comfort and overheating, respiratory and cardio diseases and the influence of built form on levels of biodiversity.

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★ Current UK BUILDING ENERGY MANAGEMENT Measures

- Energy supply from both on and off-site renewables (Limited Resource – **often** limited to the individual building)
  - Optimising the building fabric and the efficiency of energy demanding systems (*regulated*)
  - Change behaviour patterns towards energy efficient measures (*operational*)

Limited to the individual building



net-zero reductions CO2 by 2050!! / 80% of the UK 2050 building stock is already in place!

GENERIC 'ENERGY ISLAND' MEASURES ALONE ARE UNLIKELY TO BE SUFFICIENT IN REACHING TARGET REDUCTIONS - SO in an attempt to address these shortfalls, our work considers an additional but often overlooked measure;

Futcher et al 2017 Creating Sustainable Cities One Building at a Time: Towards an Integrated Urban Design Framework Cities 66:63-71

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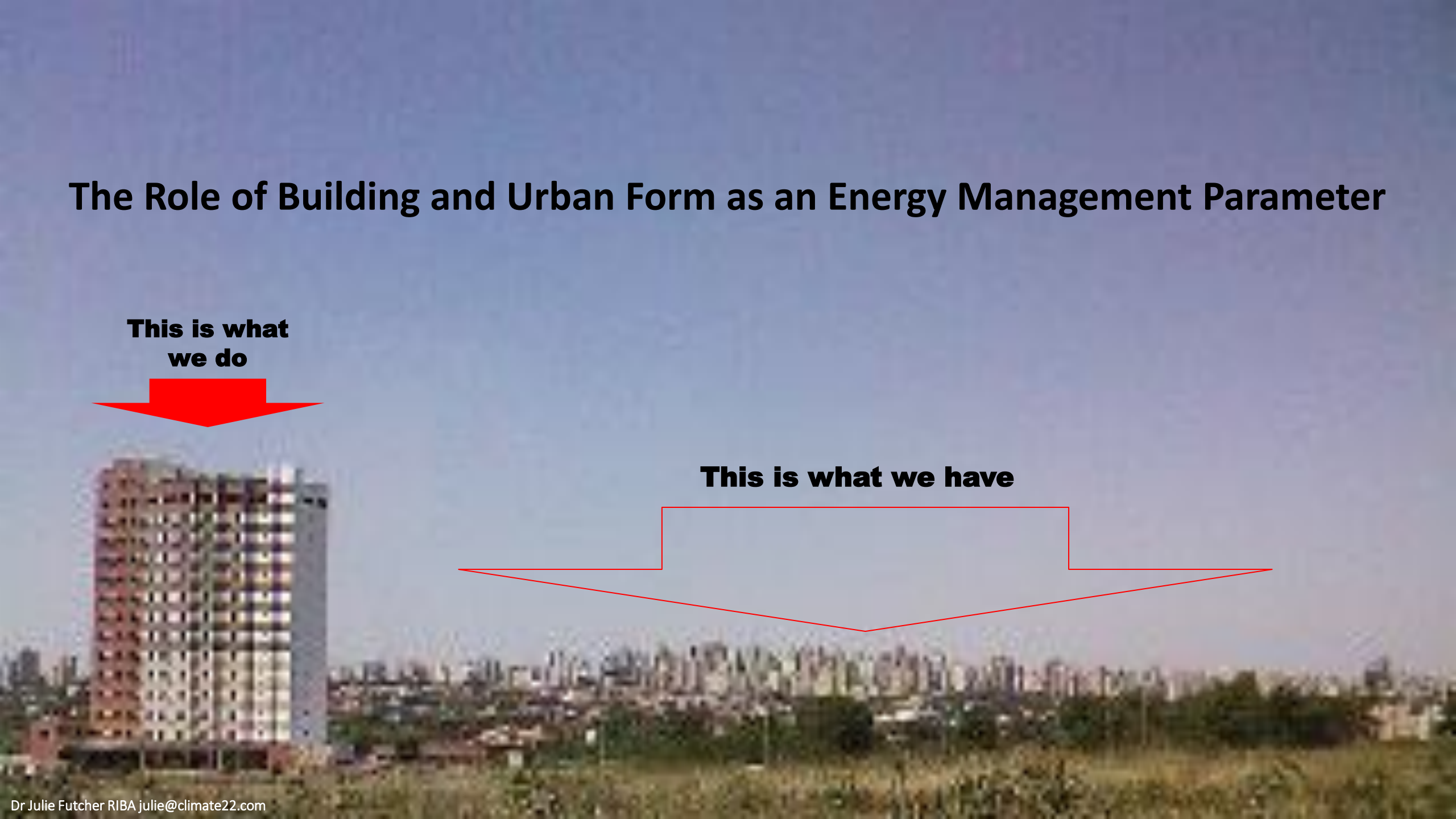
The Role of Building and Urban Form as an Energy Management Parameter



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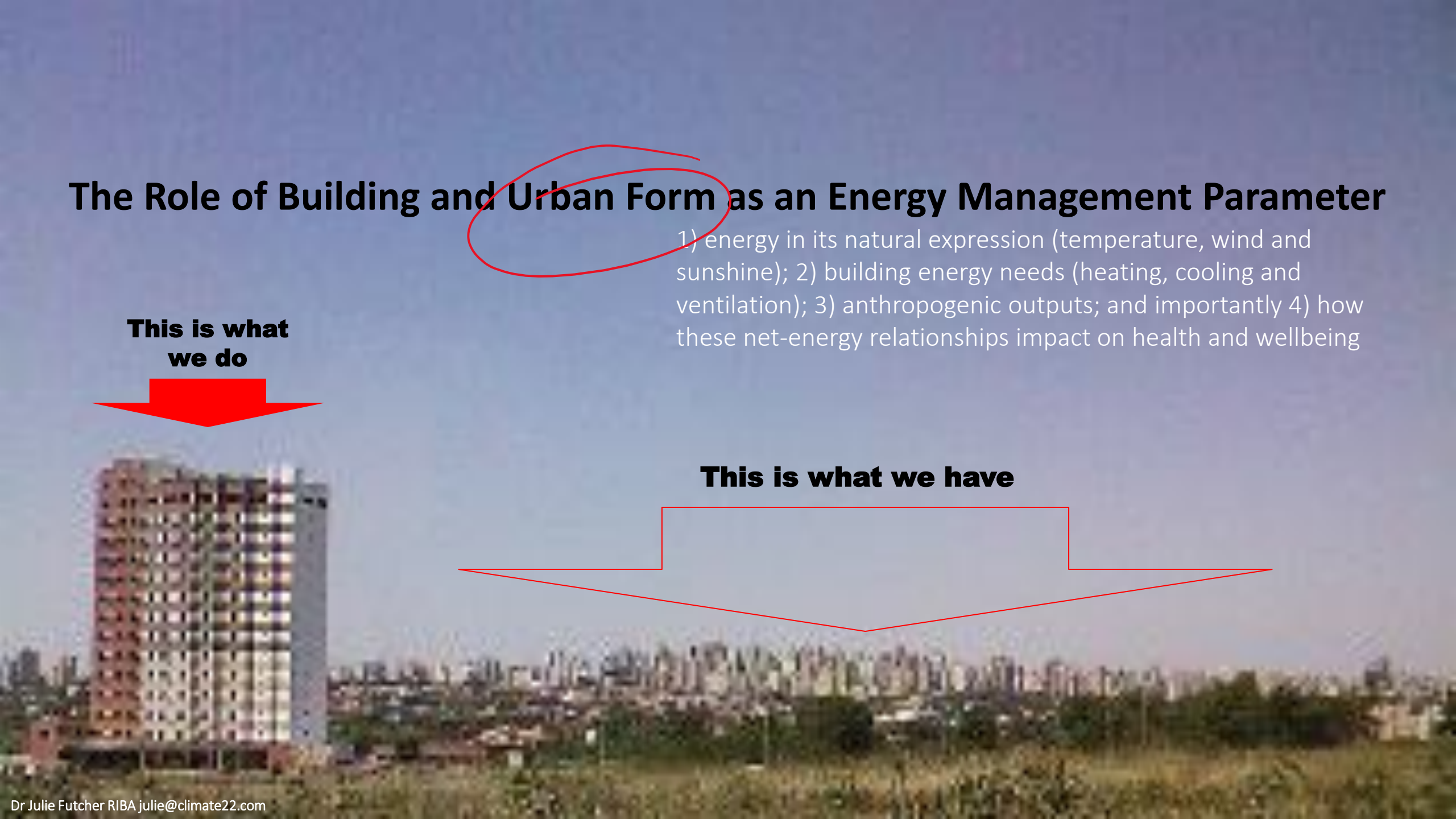
The Role of Building and Urban Form as an Energy Management Parameter

1) energy in its natural expression (temperature, wind and sunshine); 2) building energy needs (heating, cooling and ventilation); 3) anthropogenic outputs; and importantly 4) how these net-energy relationships impact on health and wellbeing

This is what we do

This is what we have



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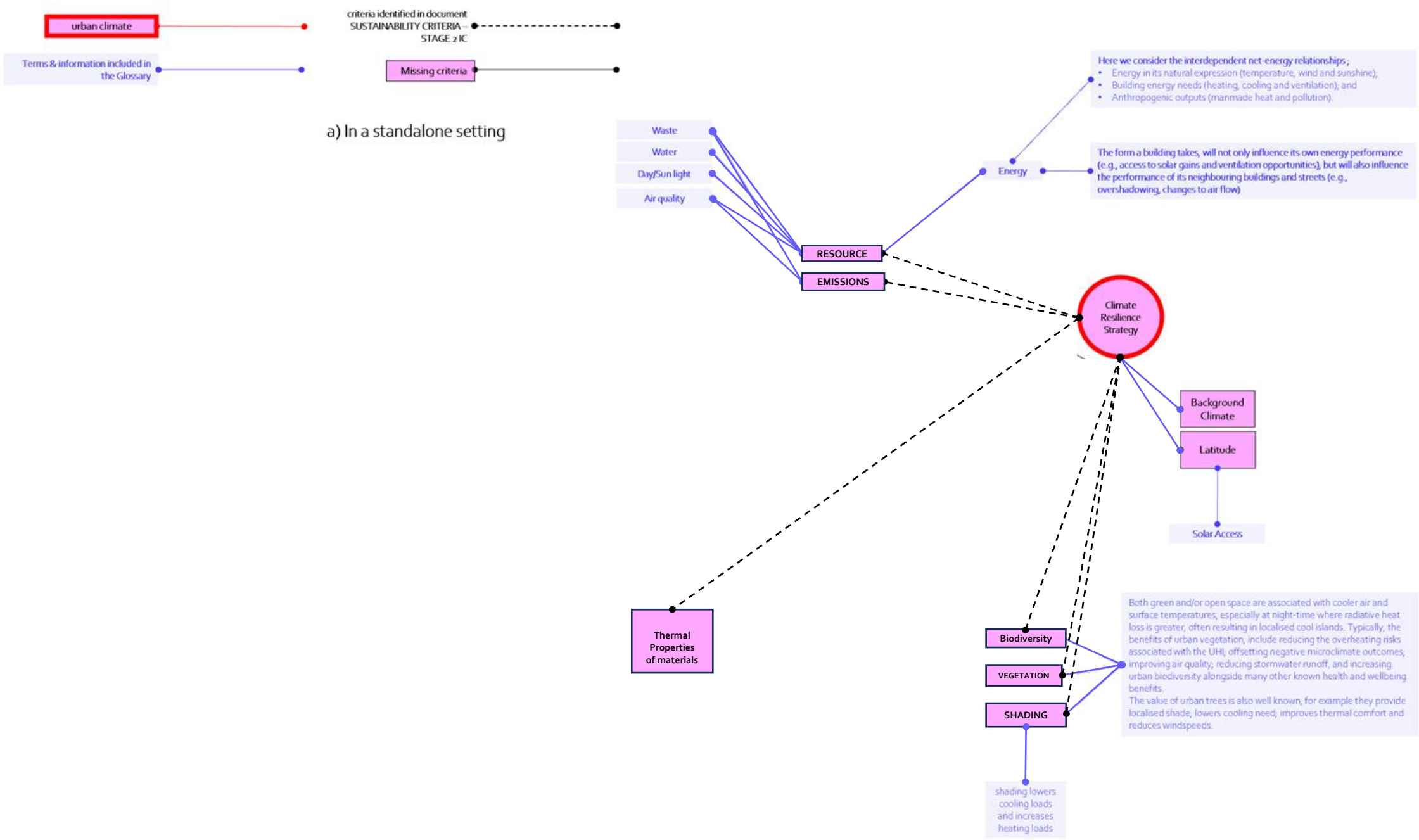

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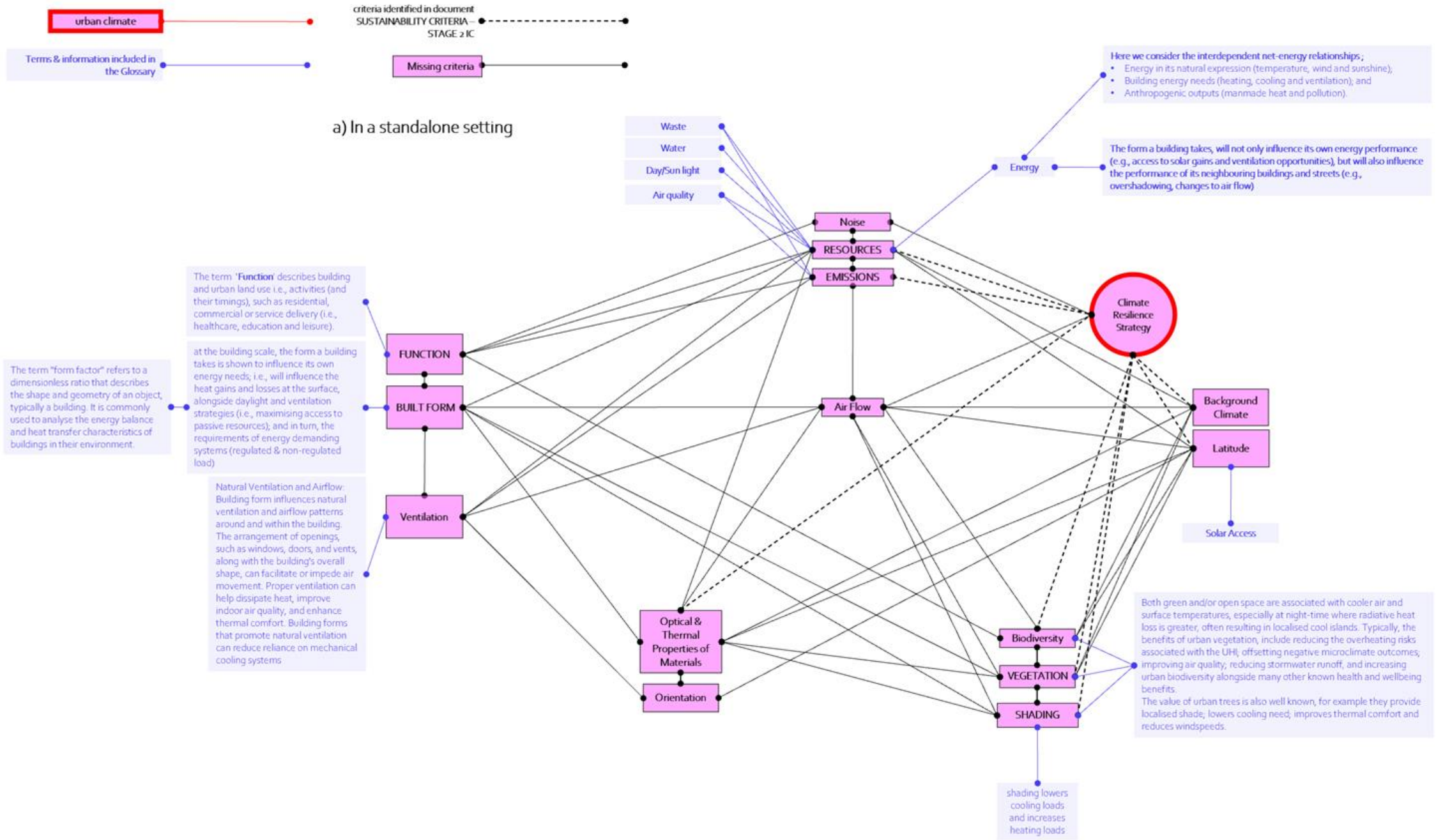

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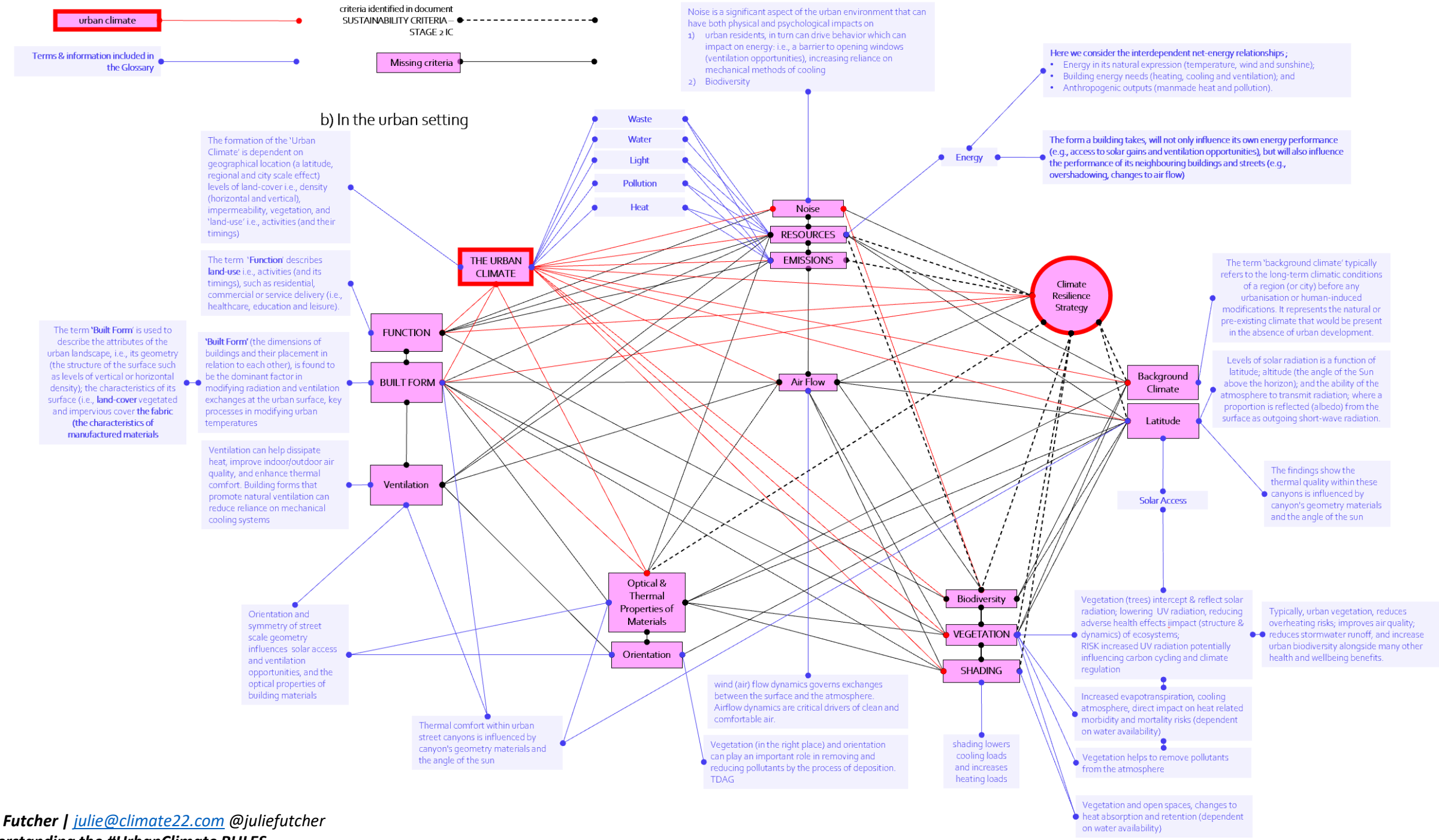

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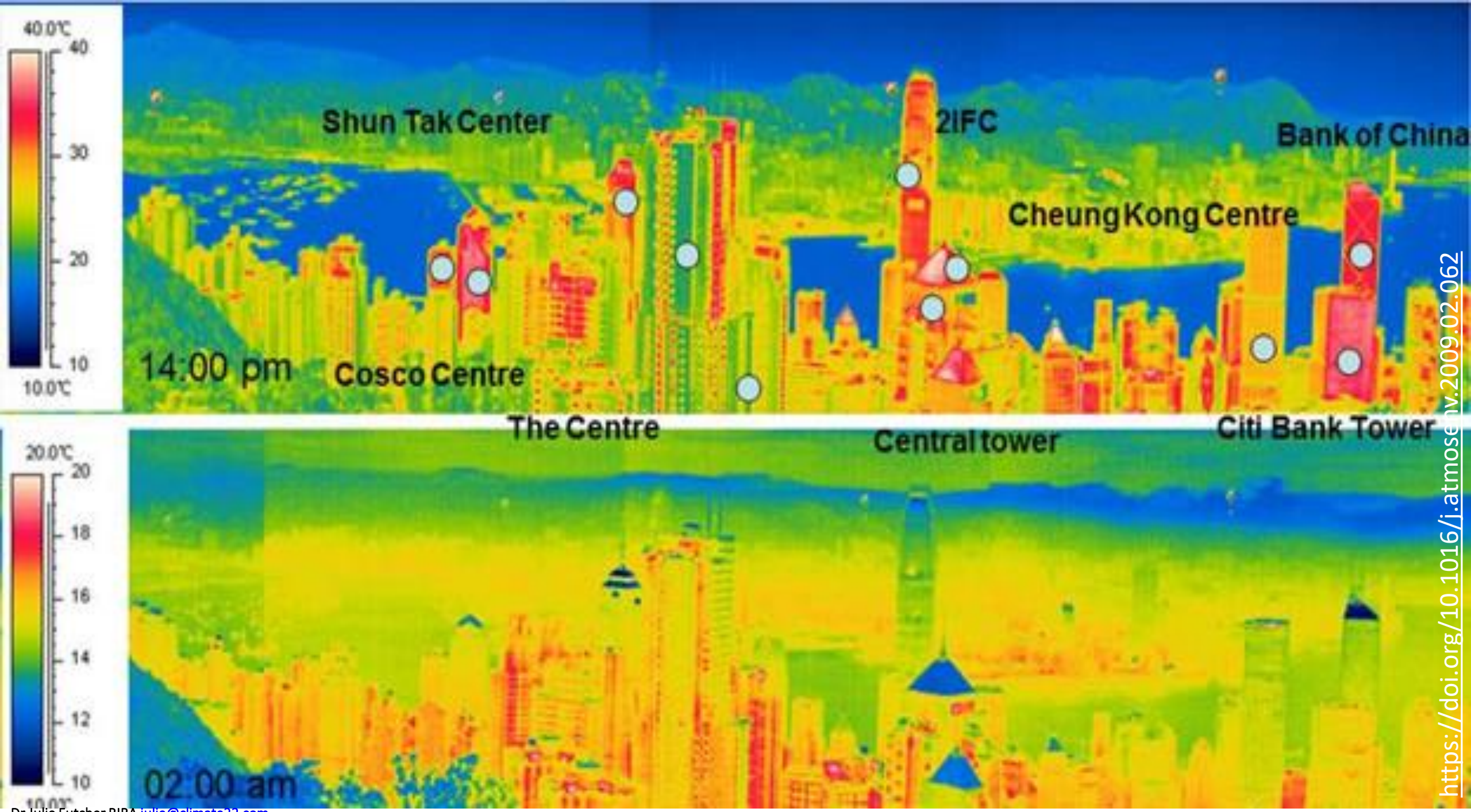

https://doi.org/10.1016/j.atmosenv.2009.02.062

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★ **THE STAND-ALONE BUILDING….**


★ Barcelona


★ Shanghai

★ Mexico City

★ Buenos Aires

https://www.over-view.com/overviews/buenos-aires?fbclid=IwAR2OKjn5do_0befXDccHSVMfeabUTpD8bTzLgh1_Q7_bLyYC9EHeU9Y7Kxk

★ BUT IF PROPERLY UNDERSTOOD!

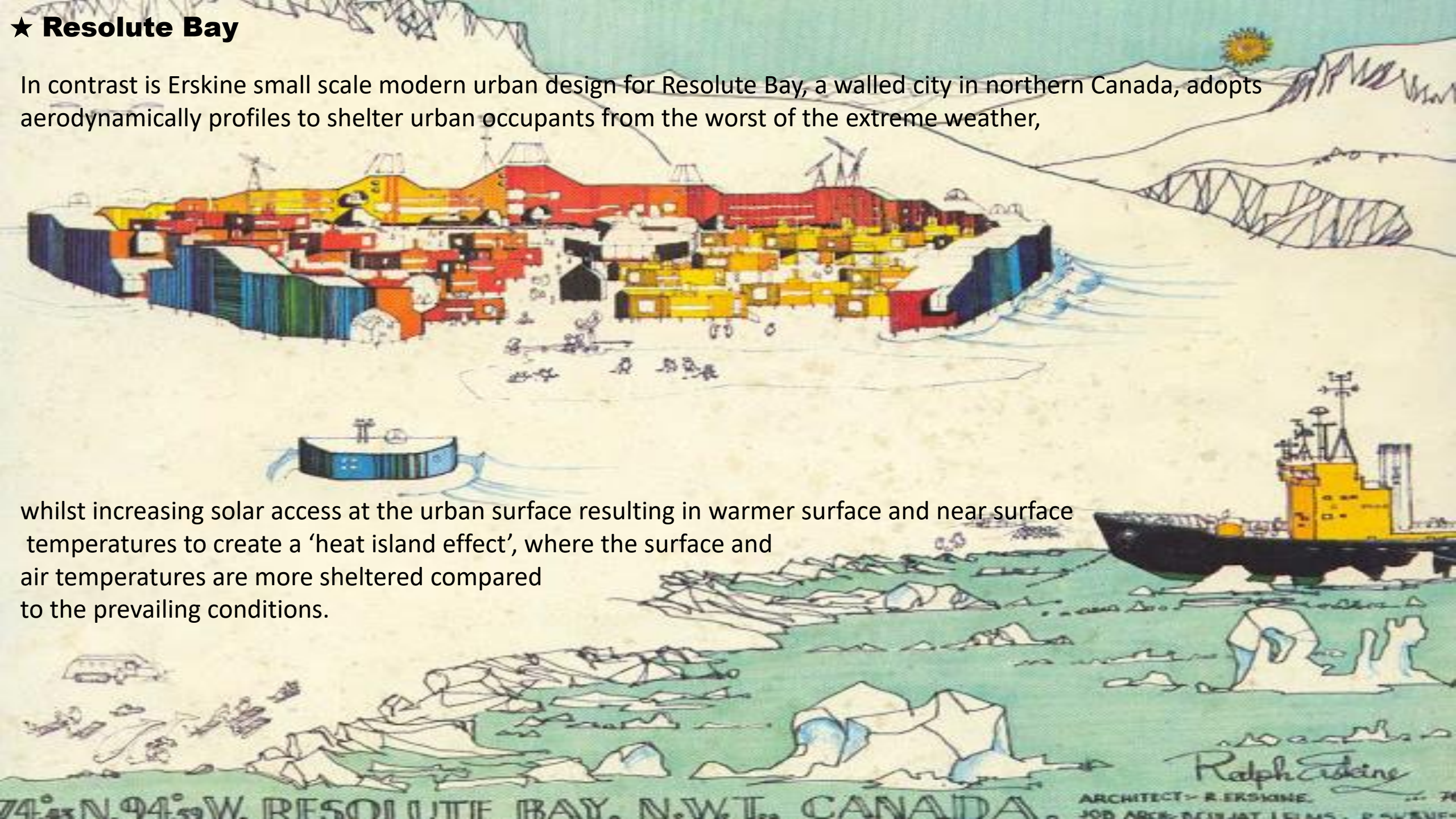
ancient city of Sanaa, Yemen ‘cool island effect’

The ancient city of Sanaa, Yemen, manages the city's internal climate through ventilation strategies and shading as a direct result of the narrow street configurations. These configurations reduce both direct and diffuse radiation at street level, lowering surface and near surface air temperatures. This cooling effect along with thermal storage results in the so called ‘cool island effect’, sheltering urban occupants from the extreme prevailing conditions.

http://www.theguardian.com/world/2010/jun/03

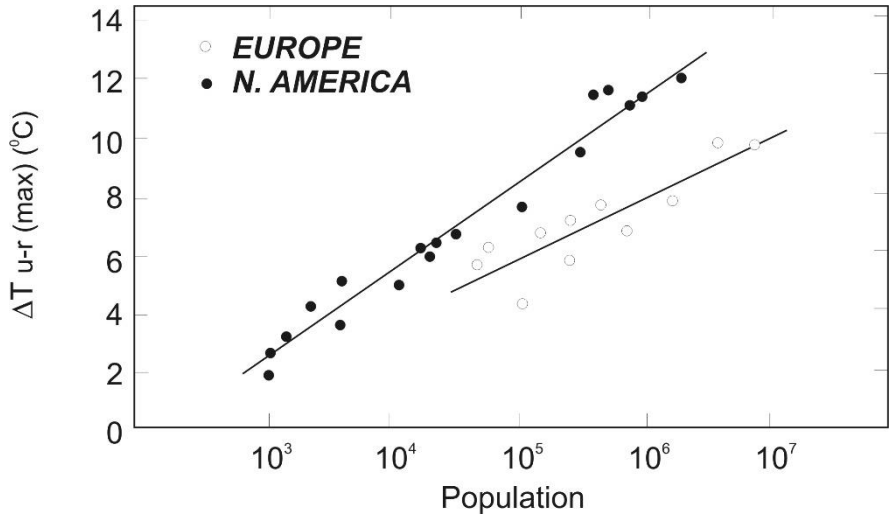
★ Resolute Bay

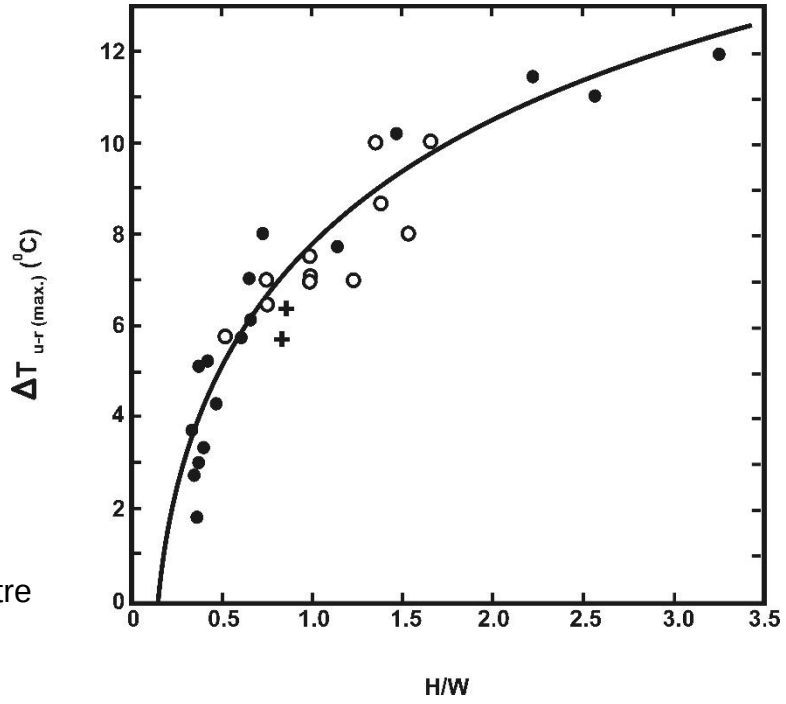
In contrast is Erskine small scale modern urban design for Resolute Bay, a walled city in northern Canada, adopts aerodynamically profiles to shelter urban occupants from the worst of the extreme weather,



whilst increasing solar access at the urban surface resulting in warmer surface and near surface temperatures to create a ‘heat island effect’, where the surface and air temperatures are more sheltered compared to the prevailing conditions.

★ NO UNIVERSAL RELATION EXISTS





This is maximum UHI intensity. H/W increases toward city centre and large H/W ratios are associated with certain building types

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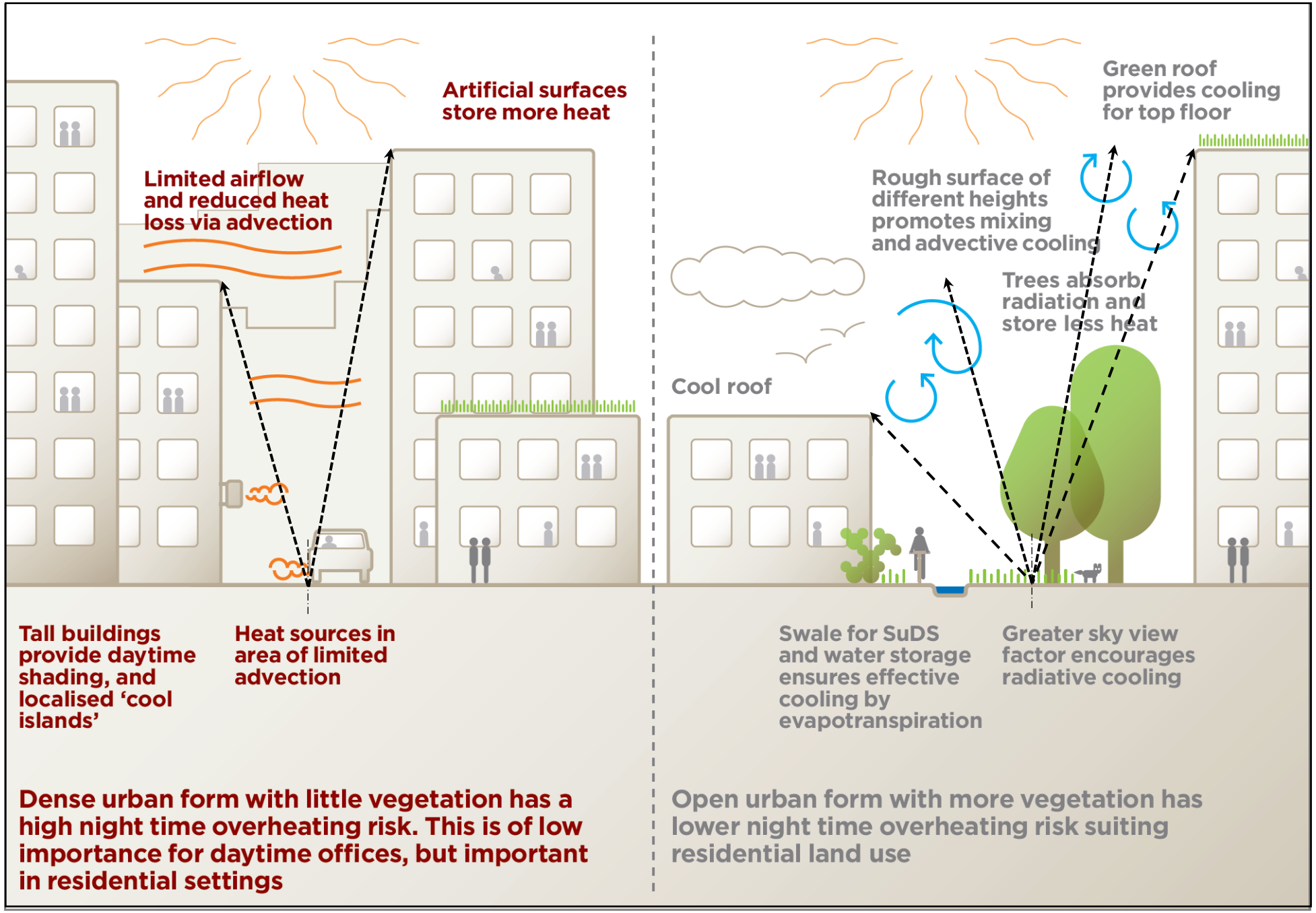
★ the value of openness to sky



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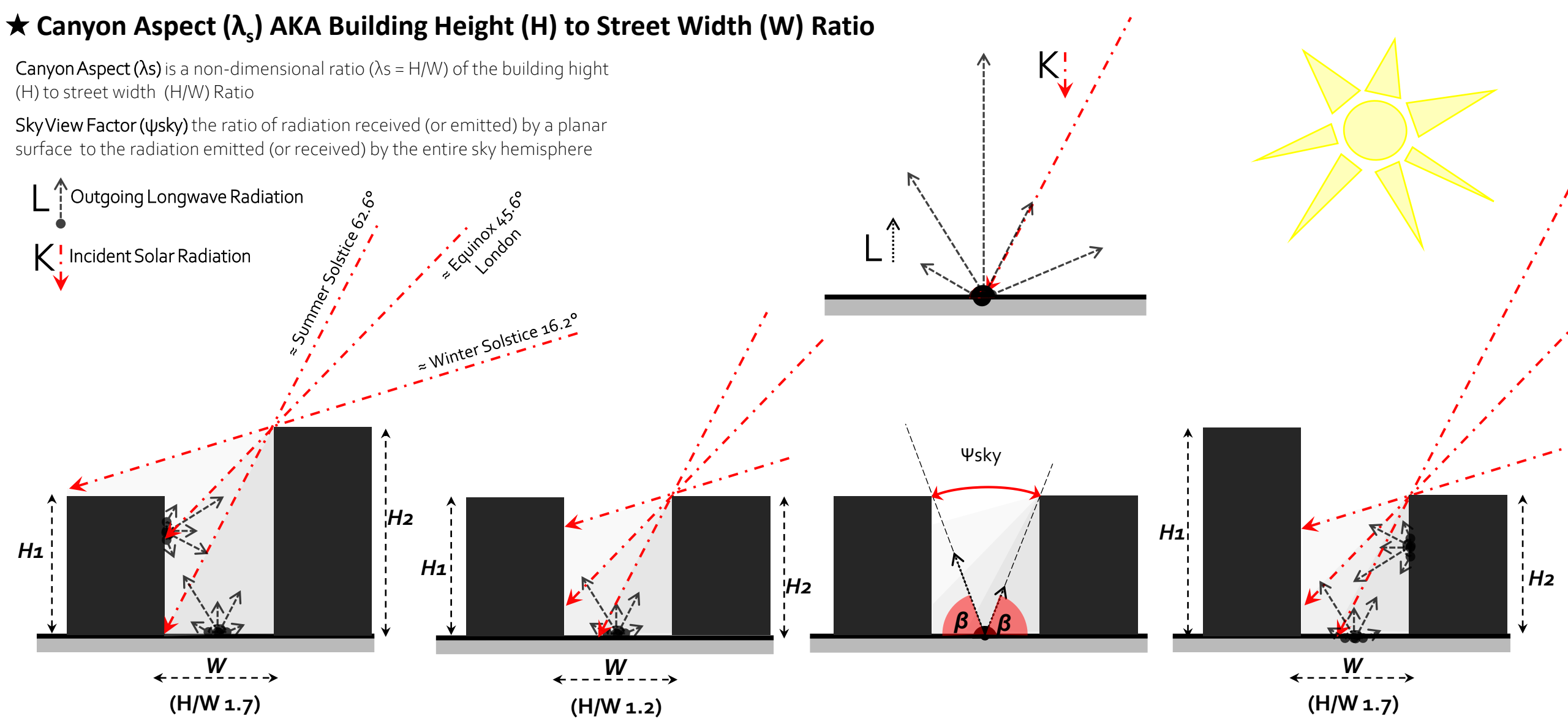
★ Canyon Aspect (λ_s) AKA Building Height (H) to Street Width (W) Ratio

Canyon Aspect (λs) is a non-dimensional ratio (λs = H/W) of the building hight (H) to street width (H/W) Ratio

Sky View Factor (ψsky) the ratio of radiation received (or emitted) by a planar surface to the radiation emitted (or received) by the entire sky hemisphere



Average $\frac{(H1 + H2)/2}{W}$

HEIGHT TO WIDTH RATIO

H/W ratio - describes street canyon density, which along with orientation (Ø) gives an idea of solar access

THE SKY VIEW FACTOR

Ψsky – is a measure of the openness of the sky to radiative transport relative to a specific location

$\psi sky = \cos \beta$

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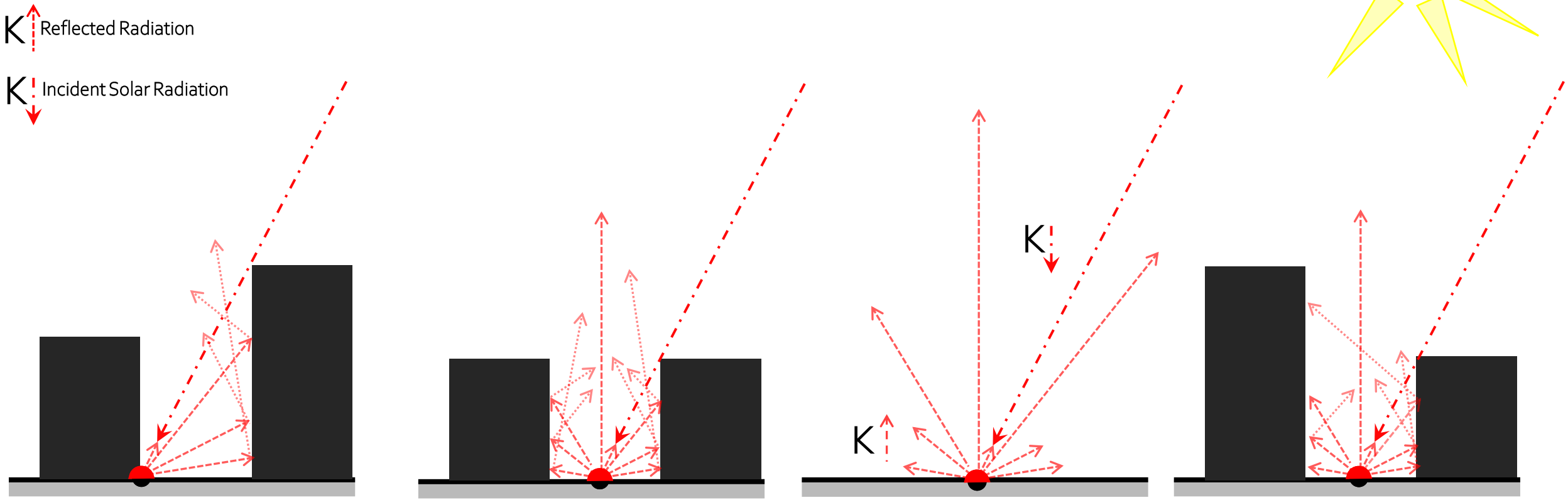
★ THE THERMAL AND OPTICAL PROPERTIES OF MATERIALS

Albedo (α) The ratio of the shortwave radiation reflected by a surface (reflectance) to the shortwave radiation reaching that surface (irradiance)



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★ Air Flow Around Buildings

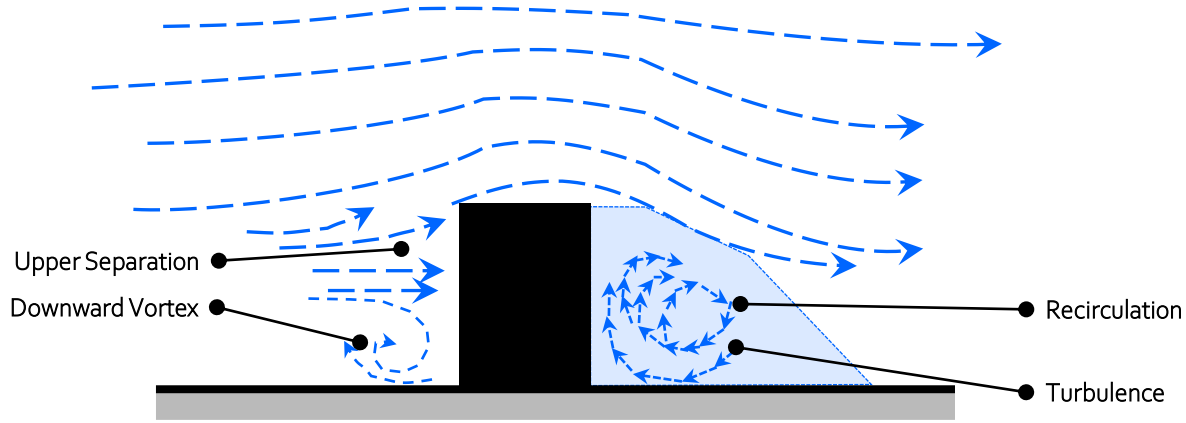
Effects of Density (H/W ratio) on Flow Regimes. Flow is driven by above roof winds .

Area of Recirculation

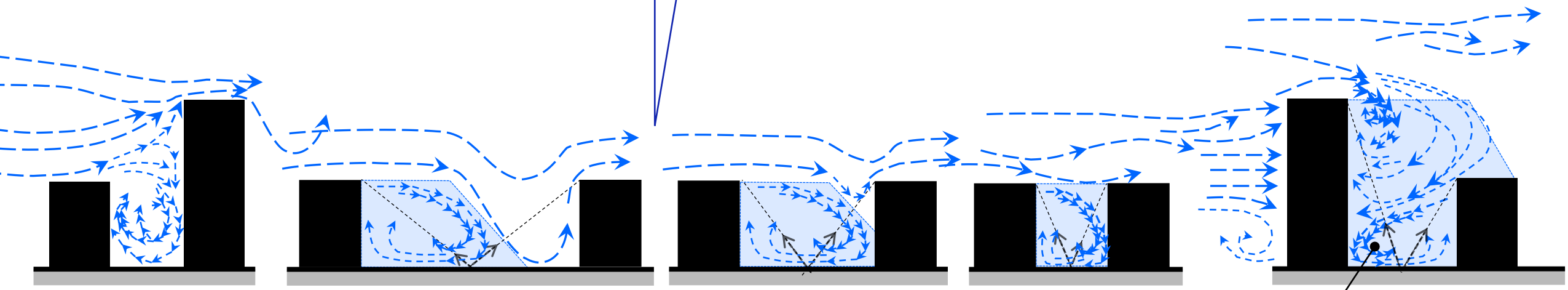
Air Flow

APPROACH FLOW

Airflow around a low building arranged in the front of a tall building. after Li, et. al., (2020); Effects of height-asymmetric street canyon configurations on outdoor air temperature and air quality



Flow Around an Isolated Building



Downdraft

Isolated Roughness Flow Regime

Wake Interference Flow Regime

Skimming Flow Regime

Area of reverse flow

Leeward Recirculation

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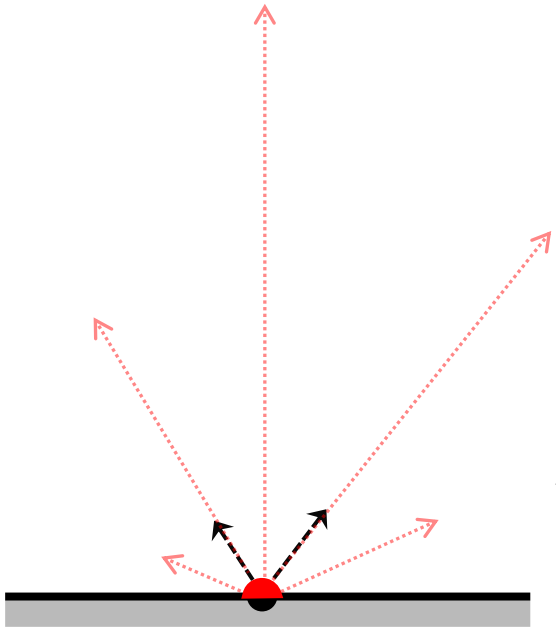
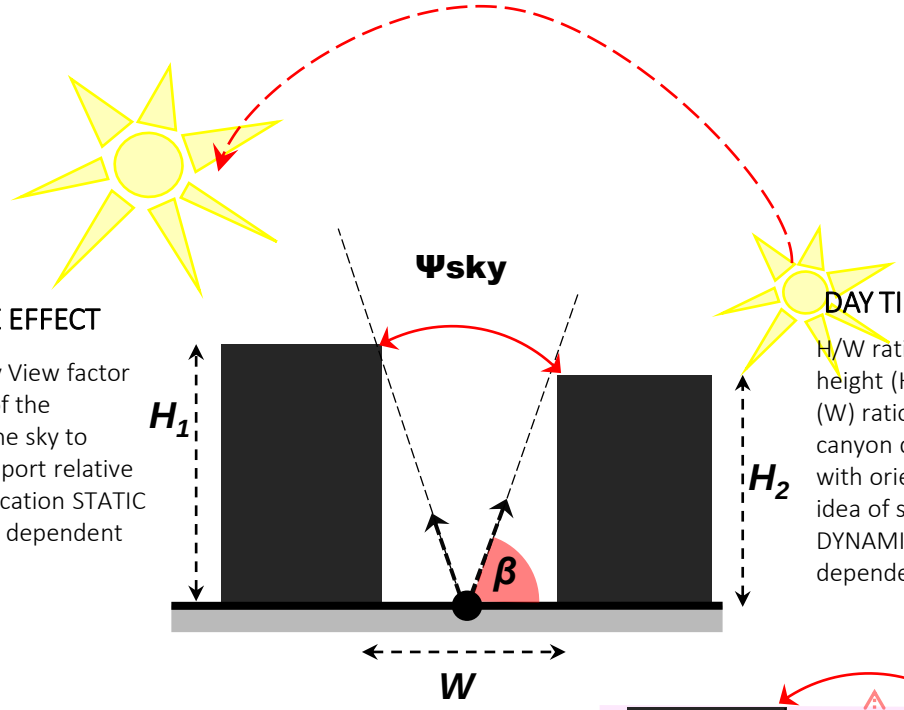
★ THE SKY VIEW FACTOR



https://www.grasshopper3d.com/group/ladybug/forum/topics/discussion-sky-view-factor

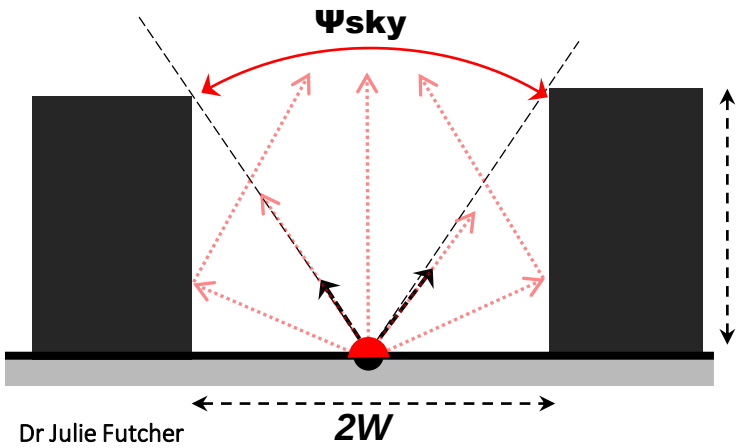
NIGHT TIME EFFECT

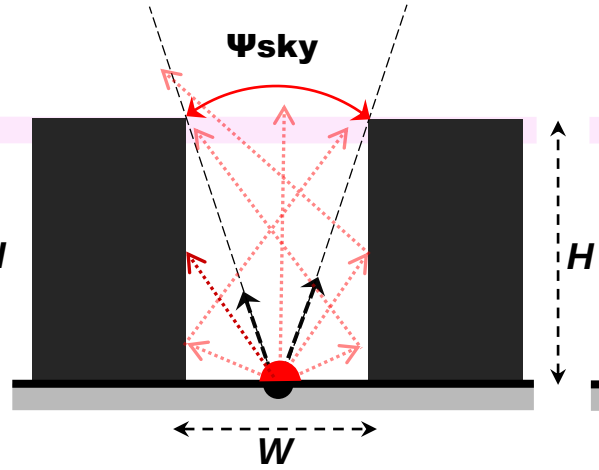
Ψsky – the Sky View factor is a measure of the openness of the sky to radiative transport relative to a specific location STATIC PARAMETER – dependent on visible sky

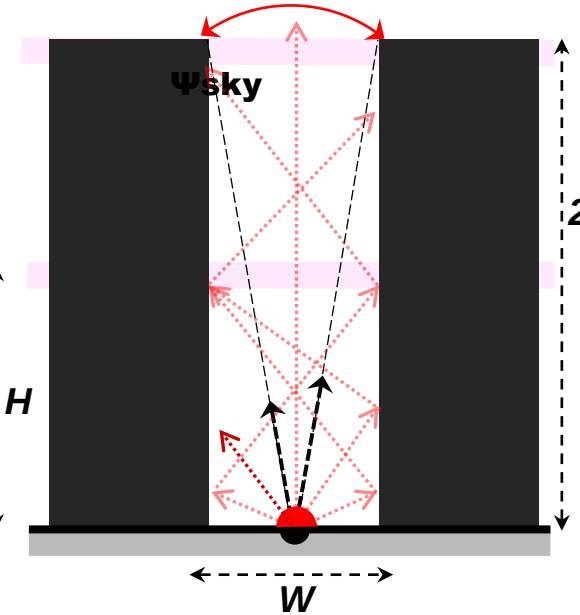


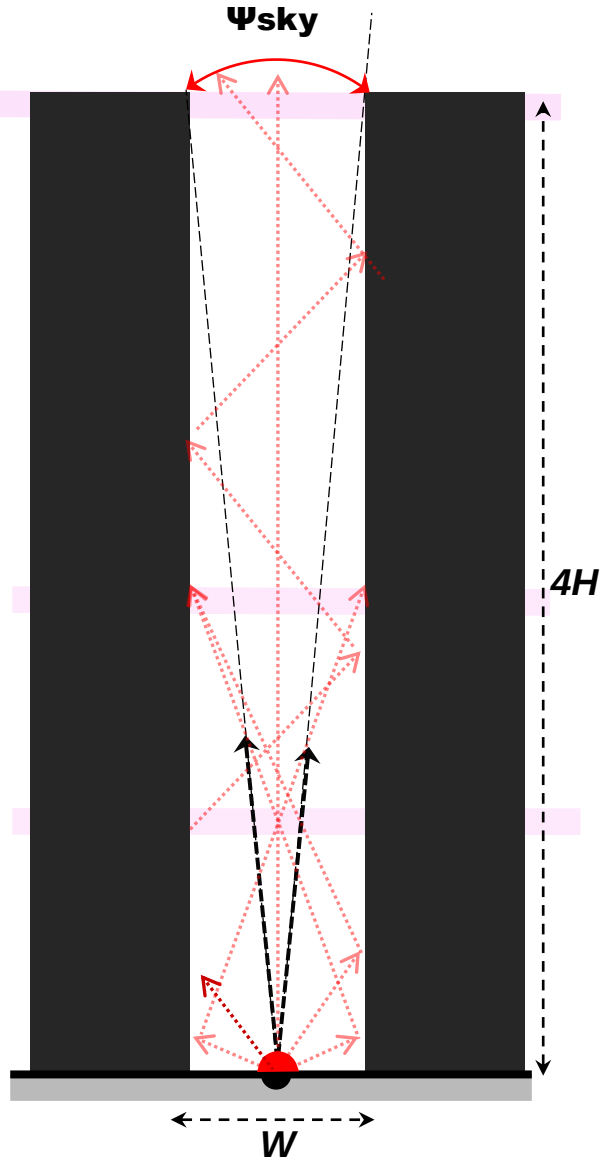
DAY TIME EFFECT

H/W ratio – mean building height (H) to street width (W) ratio describes street canyon density, which along with orientation (Ø) gives an idea of solar access - DYNAMIC PARAMETER dependent on solar access









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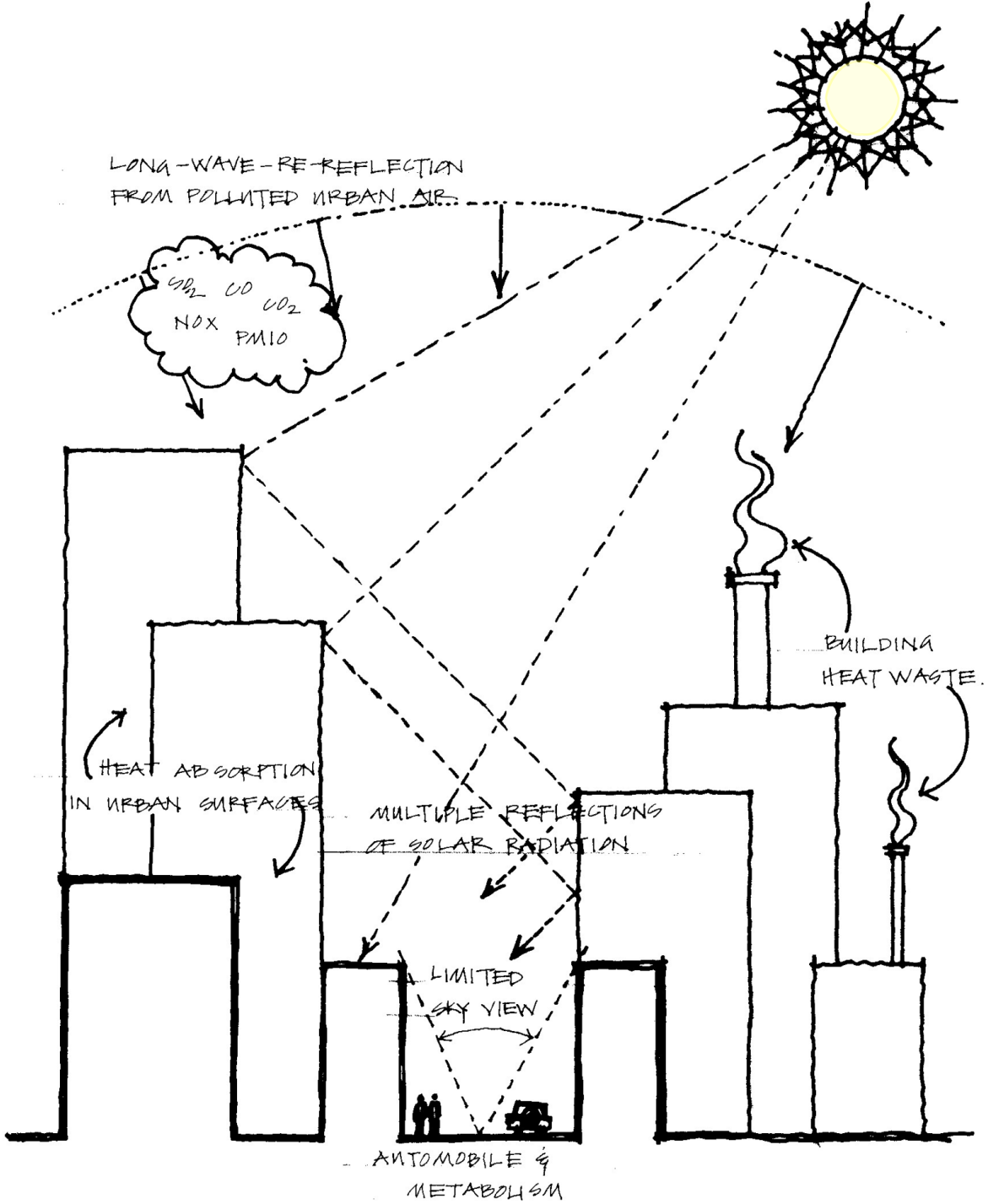
★ Drivers



Summary view of the factors affecting the urban climate. Source: Emmanuel (2005).

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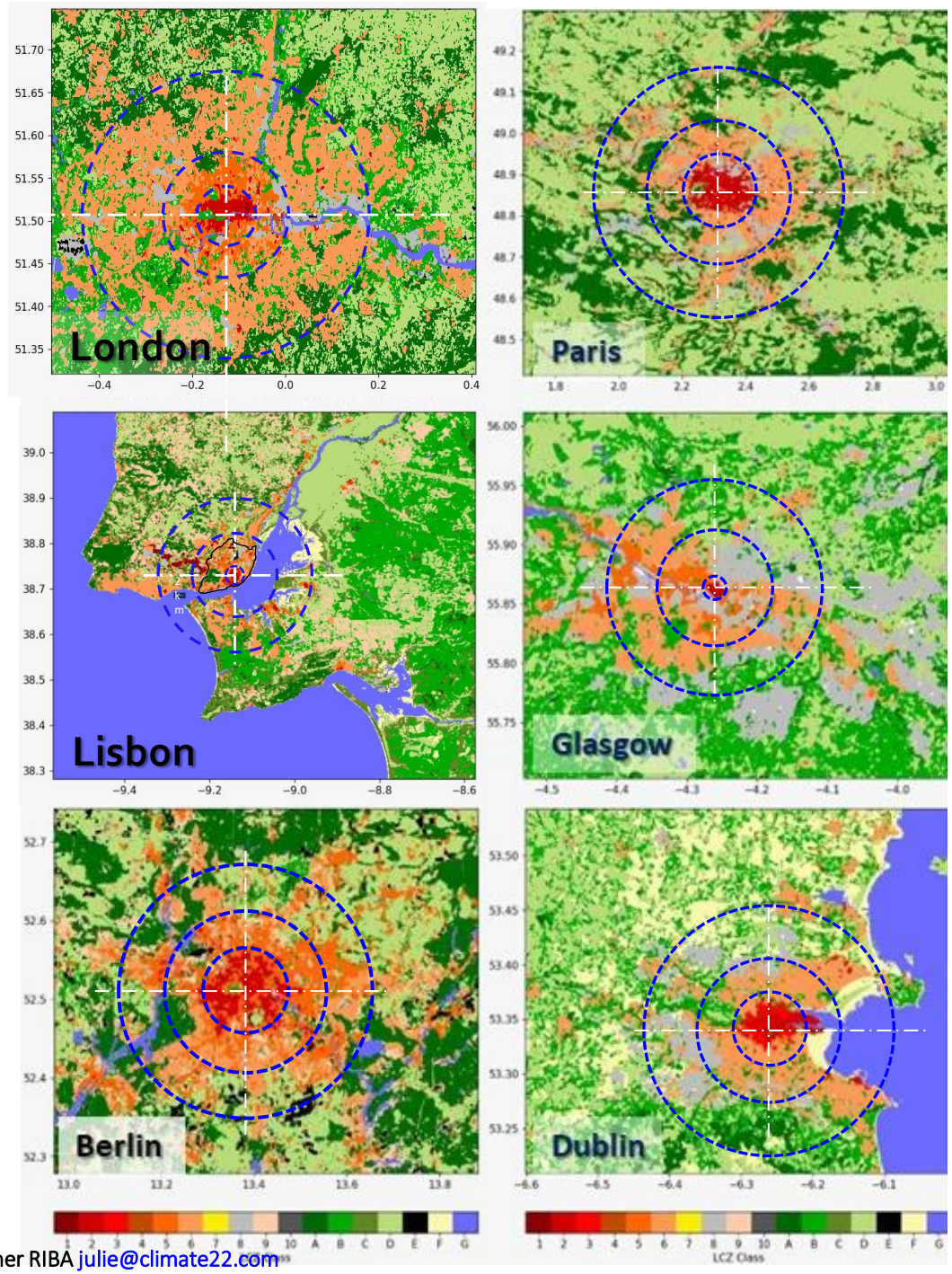
★ LCZ



Local Climate Zone		LCZ type	Building surface fraction (%)	Impervious surface fraction	Pervious surface fraction	Height of roughness elements (m)	SVF
Compact high-rise	Dense mix of tall buildings; few or no trees. Concreate, steel, stone and glass	1	40–60	40–60	<10	>25	0.2 - 0.4
Compact midrise	Dense mix of midrise buildings; few or no trees. Stone Brick, Tile, and Concreate	2	40–70	30–50	<20	10–25	0.3 - 0.6
Compact low-rise	Dense mix of low-rise buildings; few or no trees. Stone Brick, Tile, and Concreate	3	40–70	20–50	<30	3–10	0.2 - 0.6
Open high-rise	Open arrangement of tall buildings; Abundance of low plants and scattered trees. Concreate, steel, stone and glass	4	20–40	30–40	30–40	>25	0.5 - 0.7
Open midrise	Open arrangement of midrise buildings; Abundance of low plants and scattered trees. Concreate, steel, stone and glass	5	20–40	30-50	20–40	10–25	0.5 - 0.8
Open low-rise	Open arrangement of low-rise buildings; Abundance of low plants and scattered trees. Wood , Stone, Brick, Tile, and Concreate	6	20–40	20-50	30–60	3–10	0.6 - 0.9
Lightweight low-rise	Dense mix of single storey buildings; Few or no trees. Lightweight materials Wood , corrugated metal	7	60–90	,20	<30	2–4	0.2 - 0.5
Large low-rise	Open arrangement of low-rise buildings; Few or no trees. Concreate, steel, metal and stone	8	30–50	40-50	<20	3–10	> 0.7
Sparsely built	Sparce arrangement of small or medium sized buildings in a natural setting, low plants and scattered trees.	9	10–20	<20	60–80	3–10	> 0.8
Heavy industry	Low and midrise industrial structures (towers, stacks, and tanks), Few or no trees. Metal, steel and concreate	10	20–30	20-40	40–50	5–15	0.6 - 0.9
Dense trees	Natural forest. Tree cultivation, or urban park. Heavily wooded landscape of deciduous and evergreen trees.	A	<10	<10	>90	3–30	< 0.4
Scattered trees	Natural forest. Tree cultivation, or urban park. Lightly wooded landscape of deciduous and evergreen trees.	B	<10	<10	>90	3–15	0.5 - 0.8
Bush, scrub	Natural grassland or urban park. Open arrangement of bushes, shrubs and short woody trees	C	<10	<10	>90	<2	0.7 - 0.9
Low plants	Natural grassland, agriculture or urban park. Featureless landscape of grass or herbaceous plants or crops, few or no trees	D	<10	<10	>90	<1	> 0.9
Bare rock or paved	Natural desert (rock) or urban transport. Featureless landscape of rock or paved cover, few or no trees	E	<10	<90	<10	<0.25	> 0.9
Bare soil or sand	Natural desert or agriculture. Featureless landscape of soil or sand, few or no trees	F	<10	<10	>90	<0.25	> 0.9
Water	Large open water bodies such as seas and lakes, or small water bodies such as rivers, reservoirs and lagoons	G	<10	<10	>90	–	> 0.9

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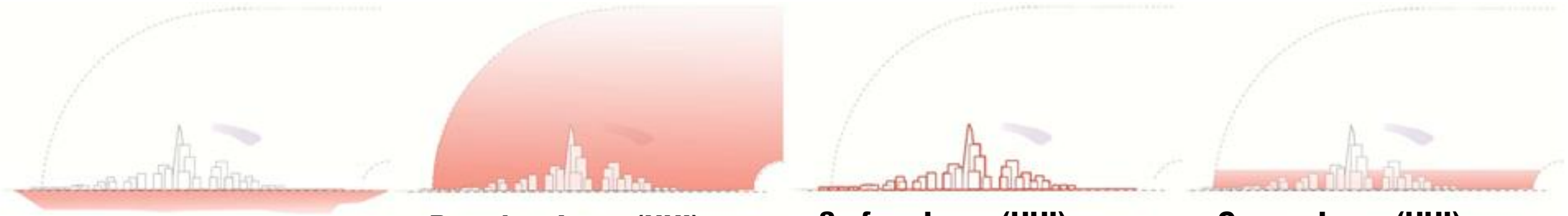
★ THE URBAN HEAT ISLAND(S)

Typical diurnal variation of Δt between an urban & rural (or non-urban site under clear sky conditions



Sub-surface Layer (UHI)

Boundary Layer (UHI)

Daytime surface warming heats the overlying atmosphere

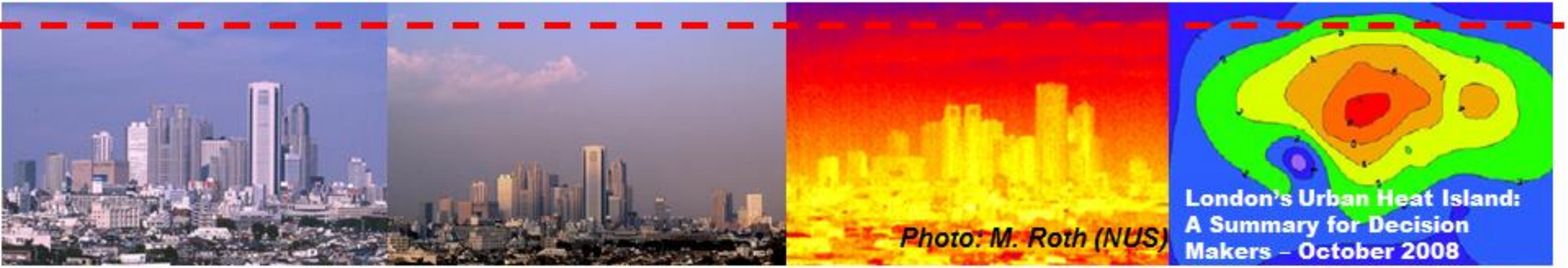
Surface Layer (UHI)

Climates in the surface layer are characterised by great temporal and spatial variations

Canopy Layer (UHI)

The best known of the local urban effects

Top of urban boundary layer (UBL)



Shinjuku (Tokyo), early October 1998 during late afternoon

It is worth pointing out the well-known UHI phenomenon is frequently misunderstood in terms of type (surface or air), timing (daytime or night-time) and cause (natural energy exchanges or anthropogenic heating).

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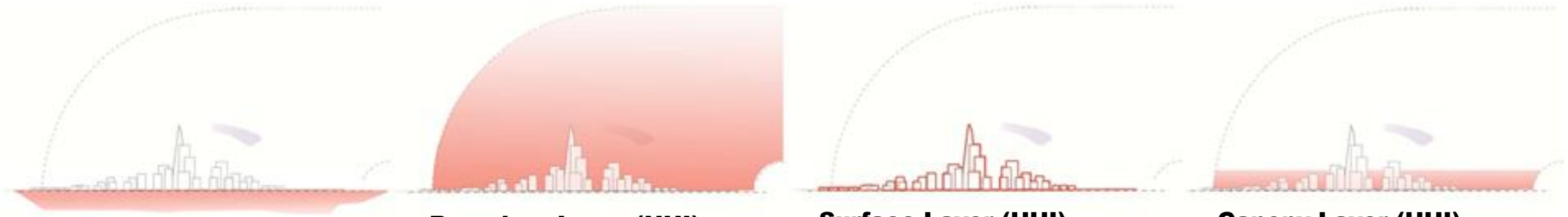

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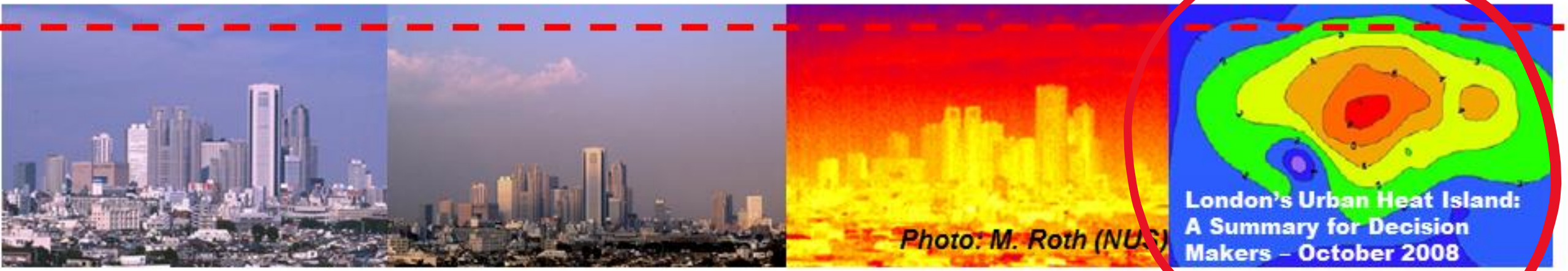

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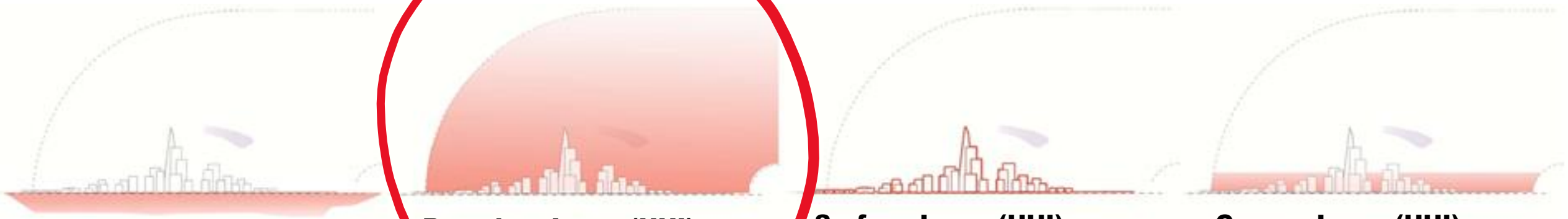

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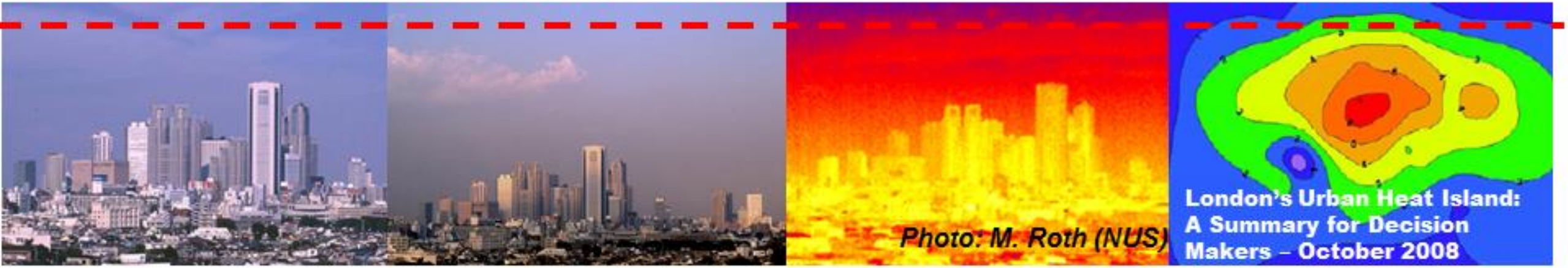

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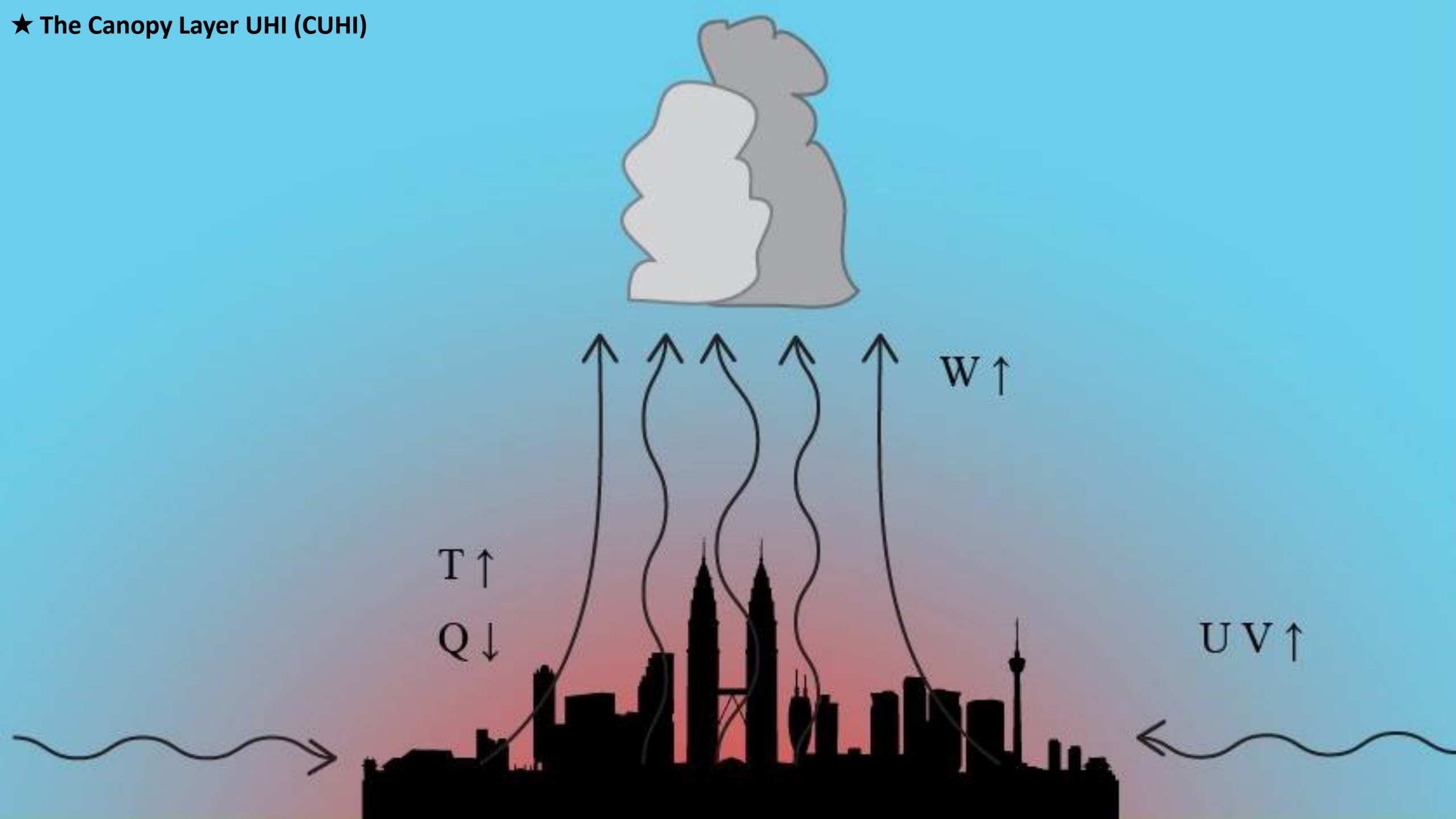
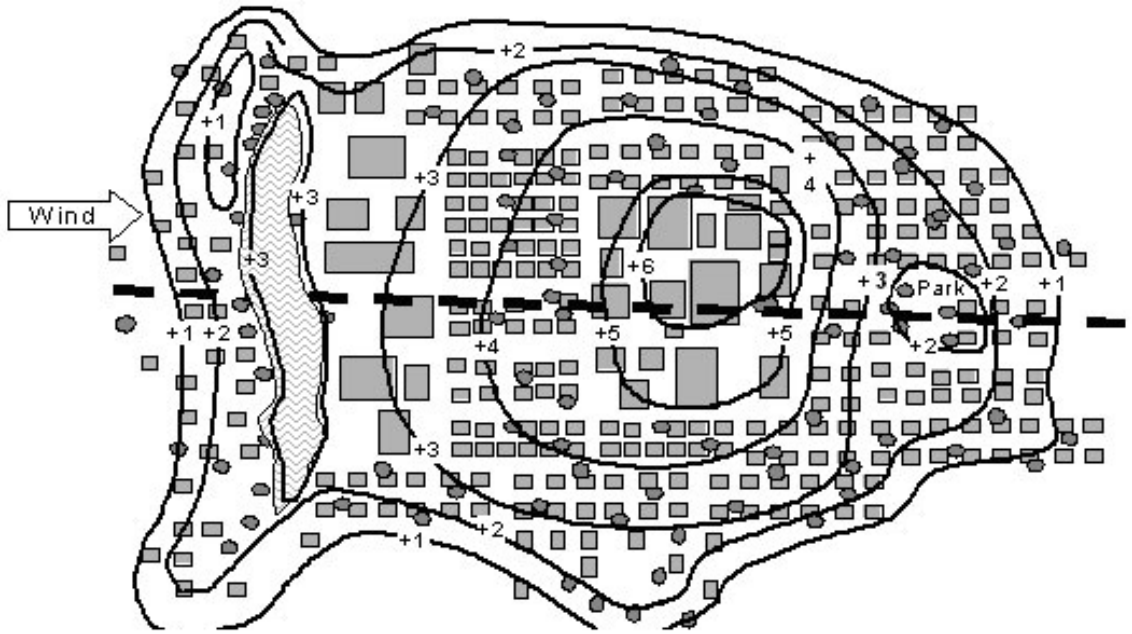
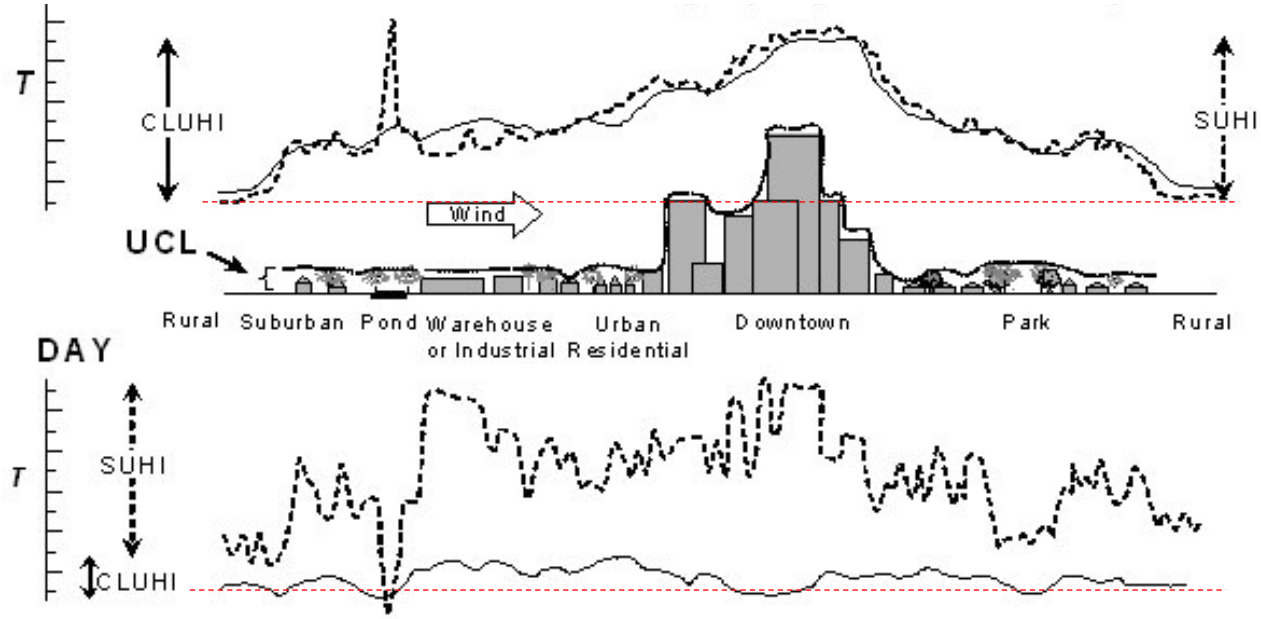
★ The Canopy Layer UHI (CUHI)

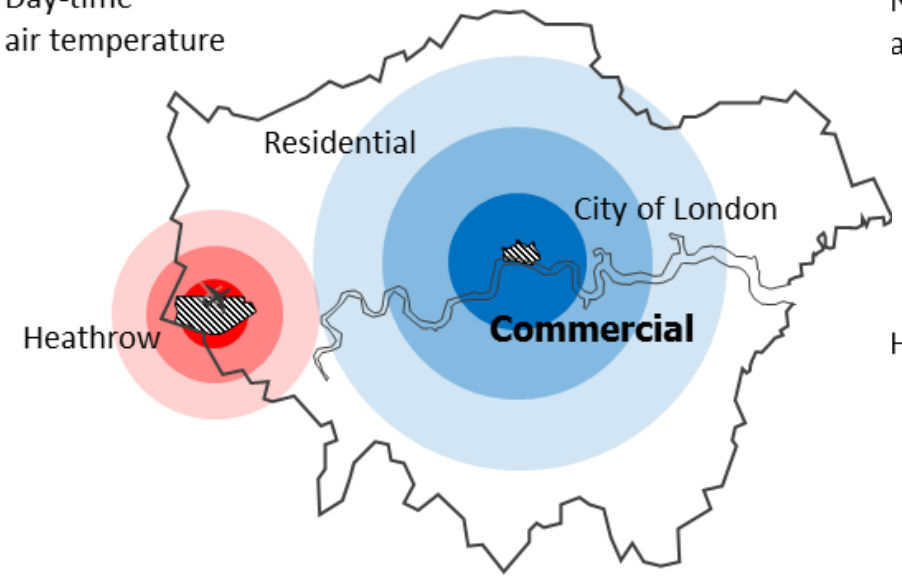


★ the TIMING of the Urban Climate Effects

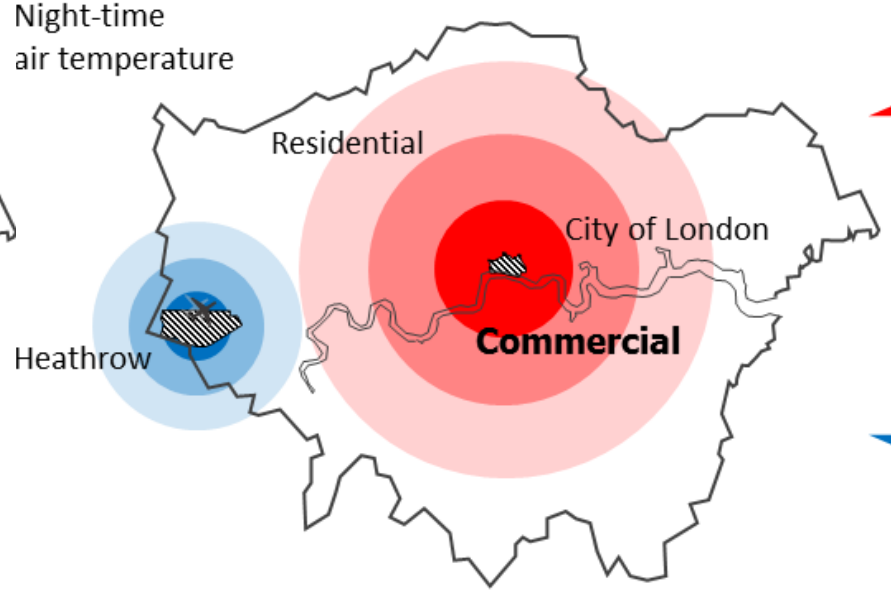


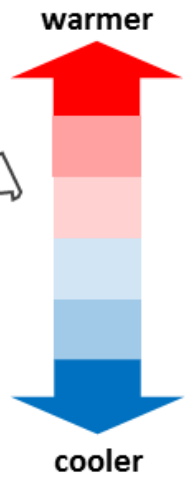


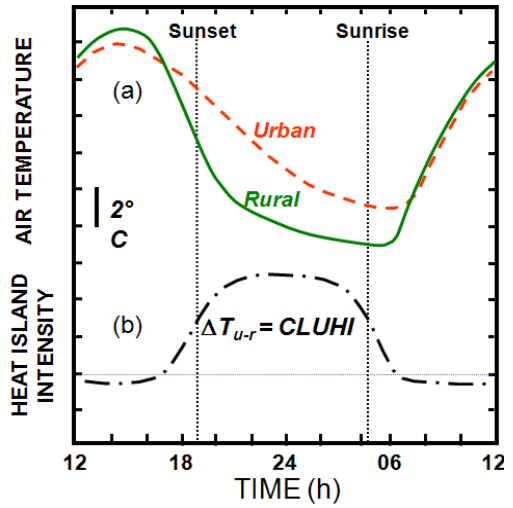
Day-time
air temperature



Night-time
air temperature







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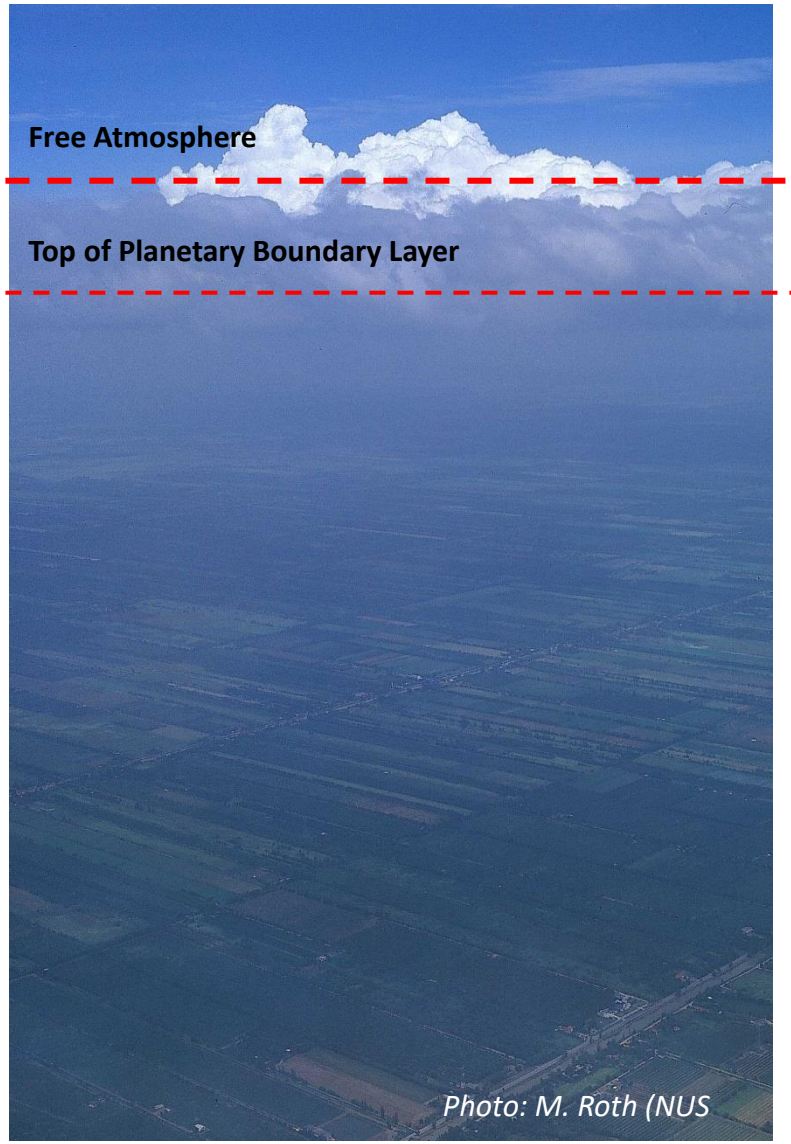
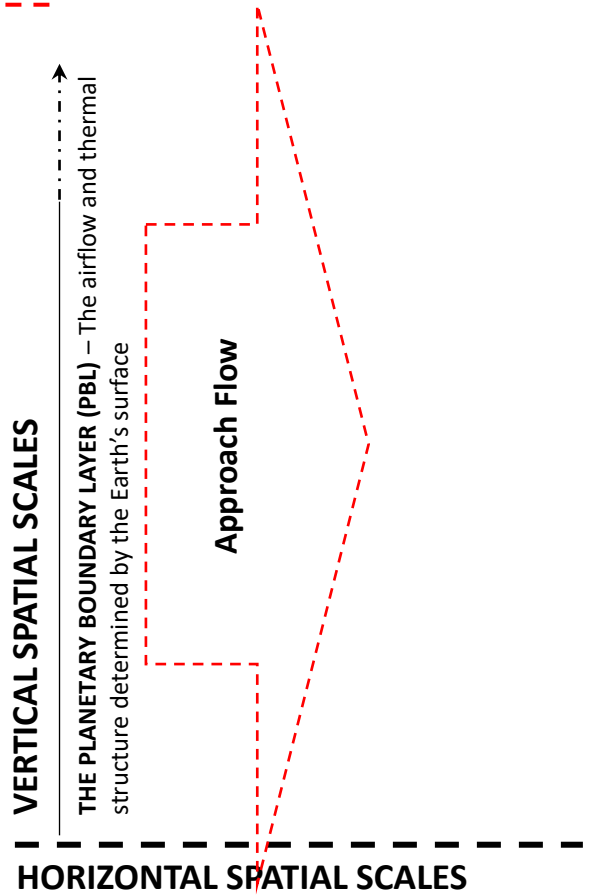
★ SCHEMATIC STRUCTURE OF THE LOWER ATMOSPHERE





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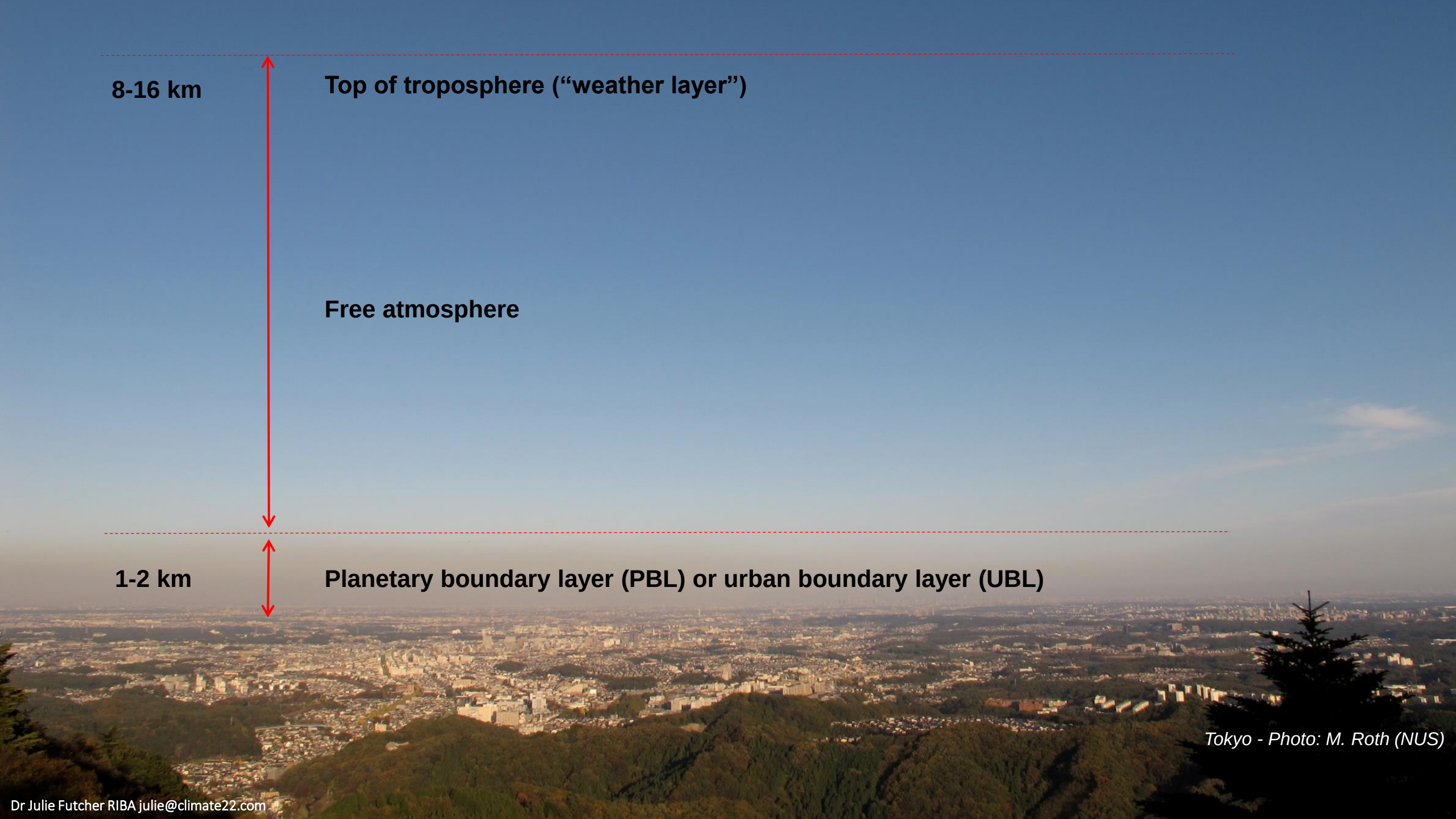

Tokyo - Photo: M. Roth (NUS)

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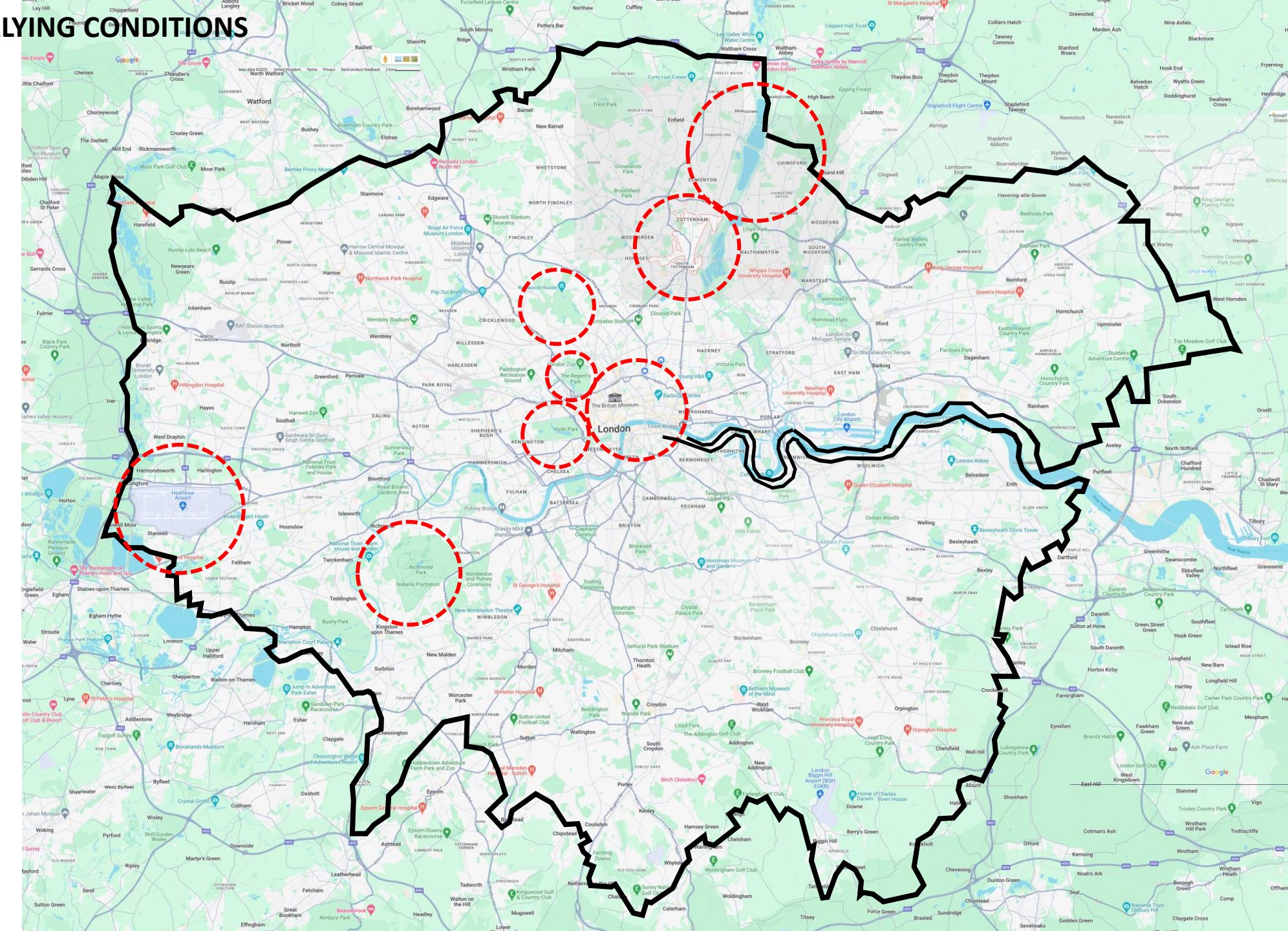
★ DEPENDENCY ON UNDERLYING CONDITIONS



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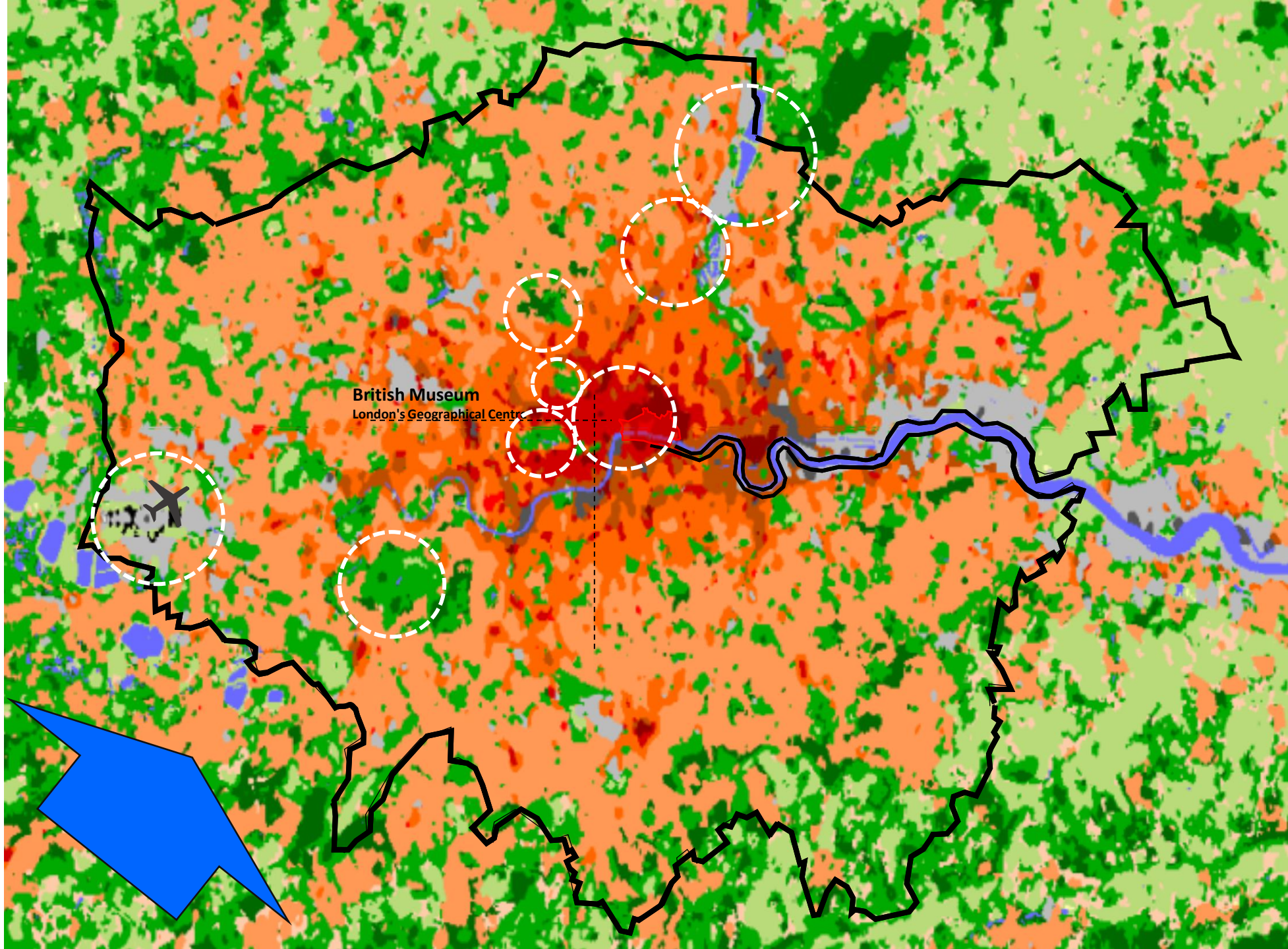
★ **LCZ's**

http://www.wudapt.org/



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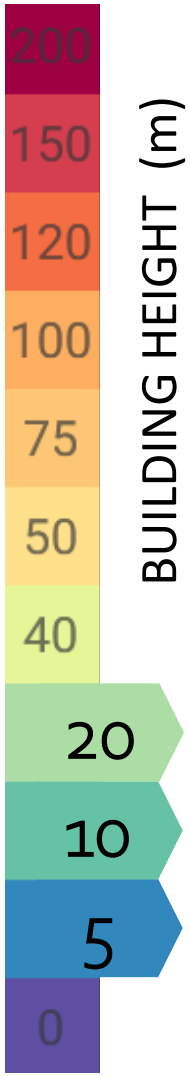

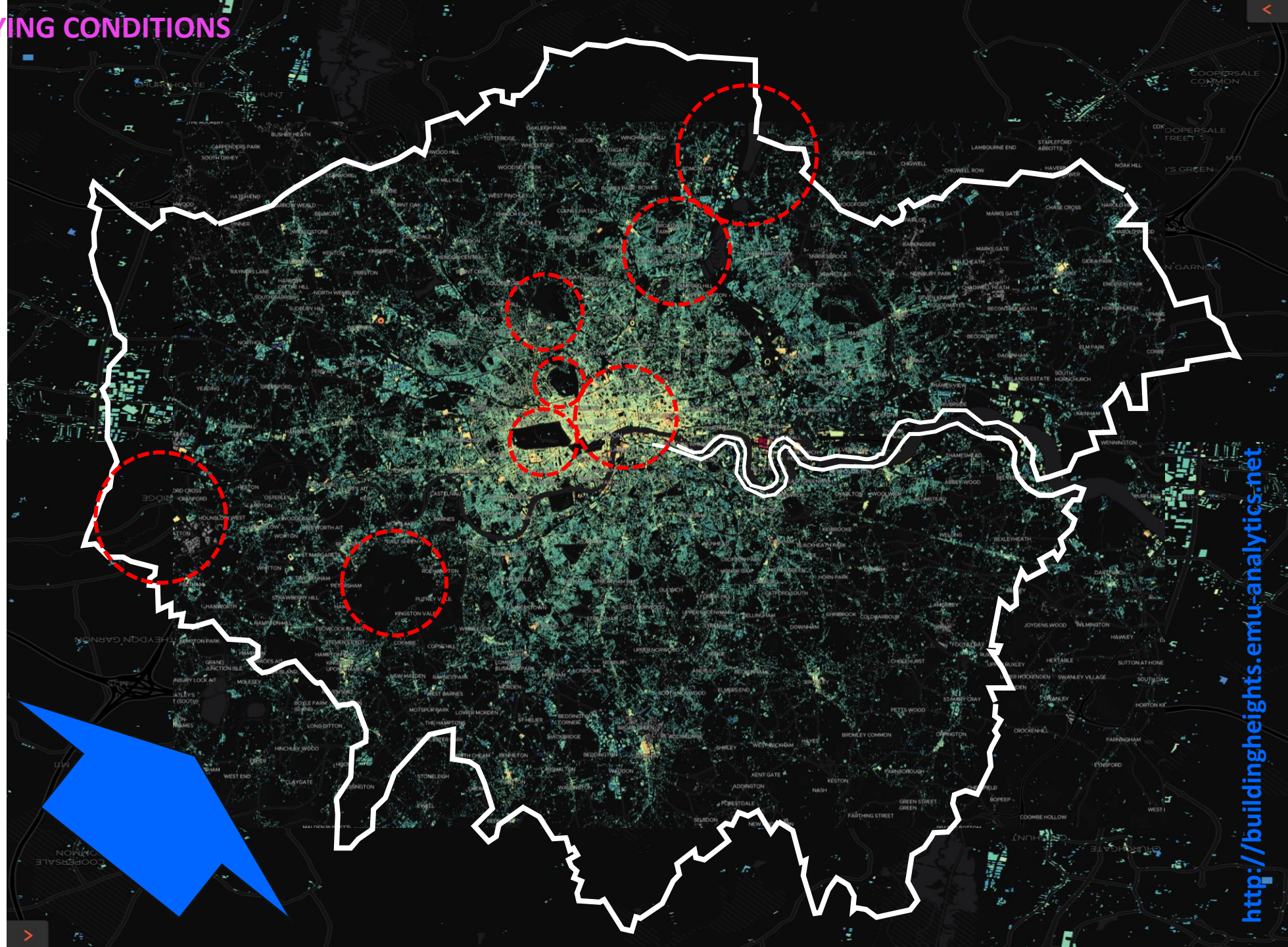

http://buildingheights.emu-analytics.net

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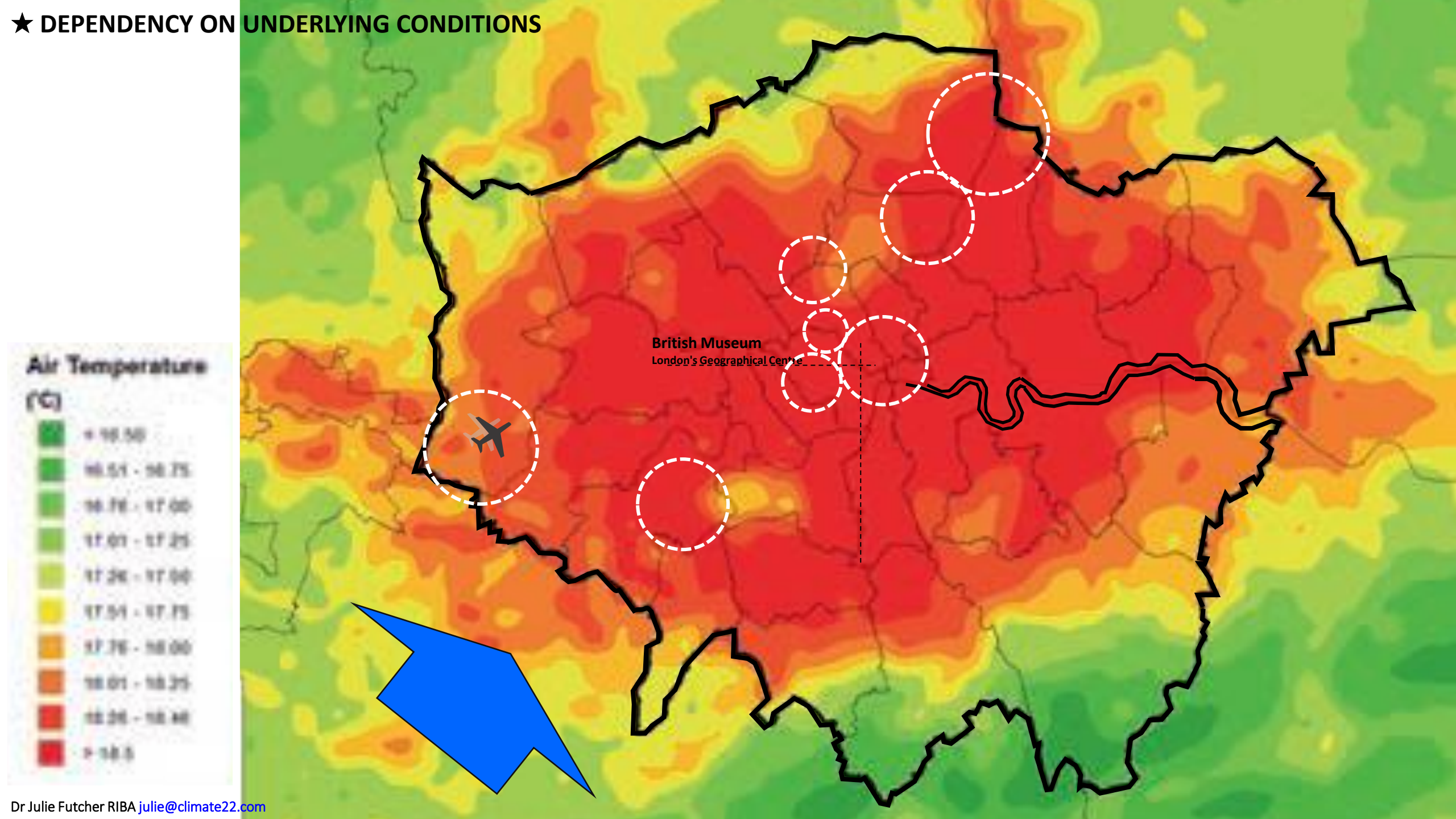

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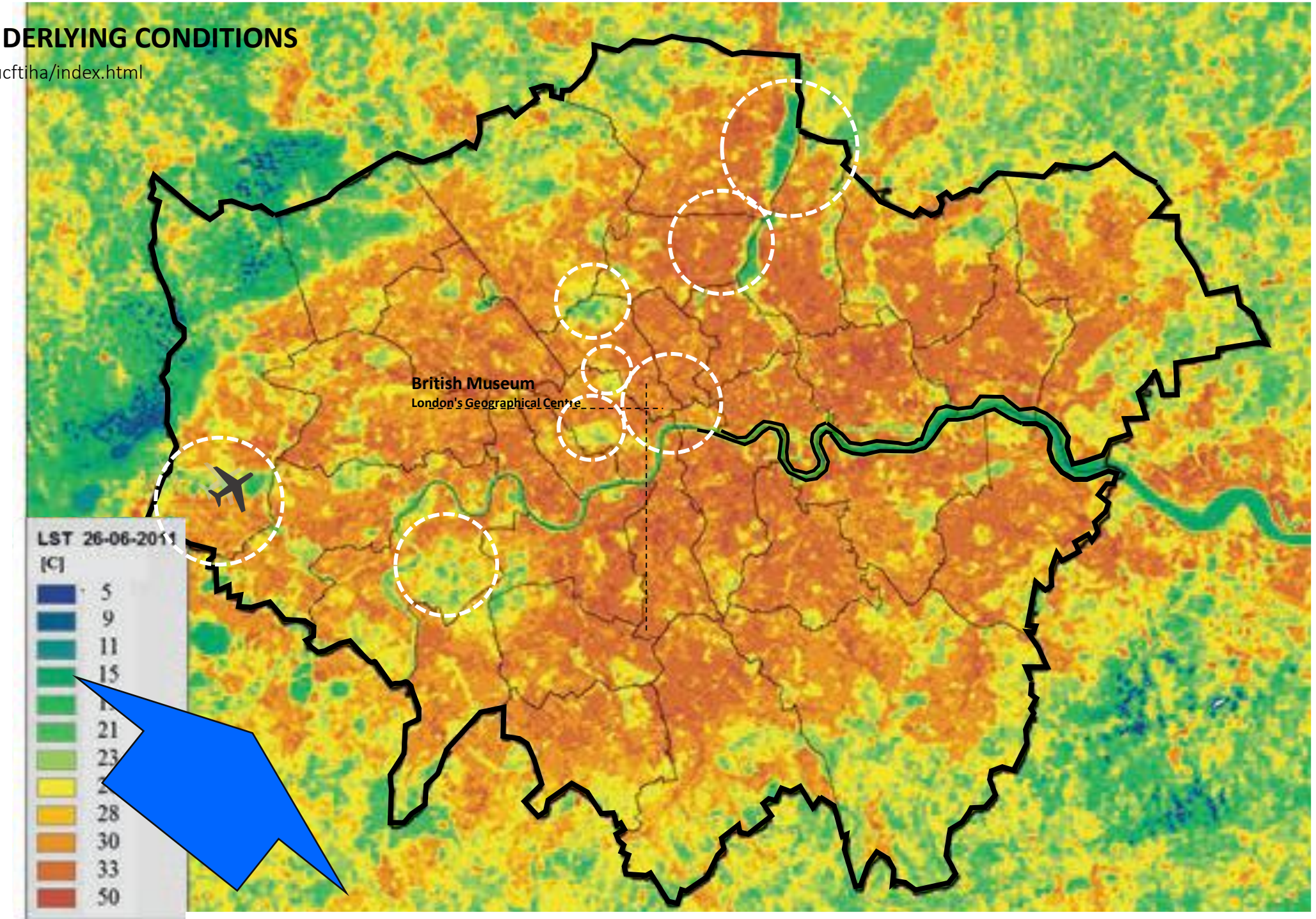
http://www.homepages.ucl.ac.uk/~ucftiha/index.html



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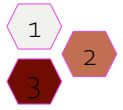
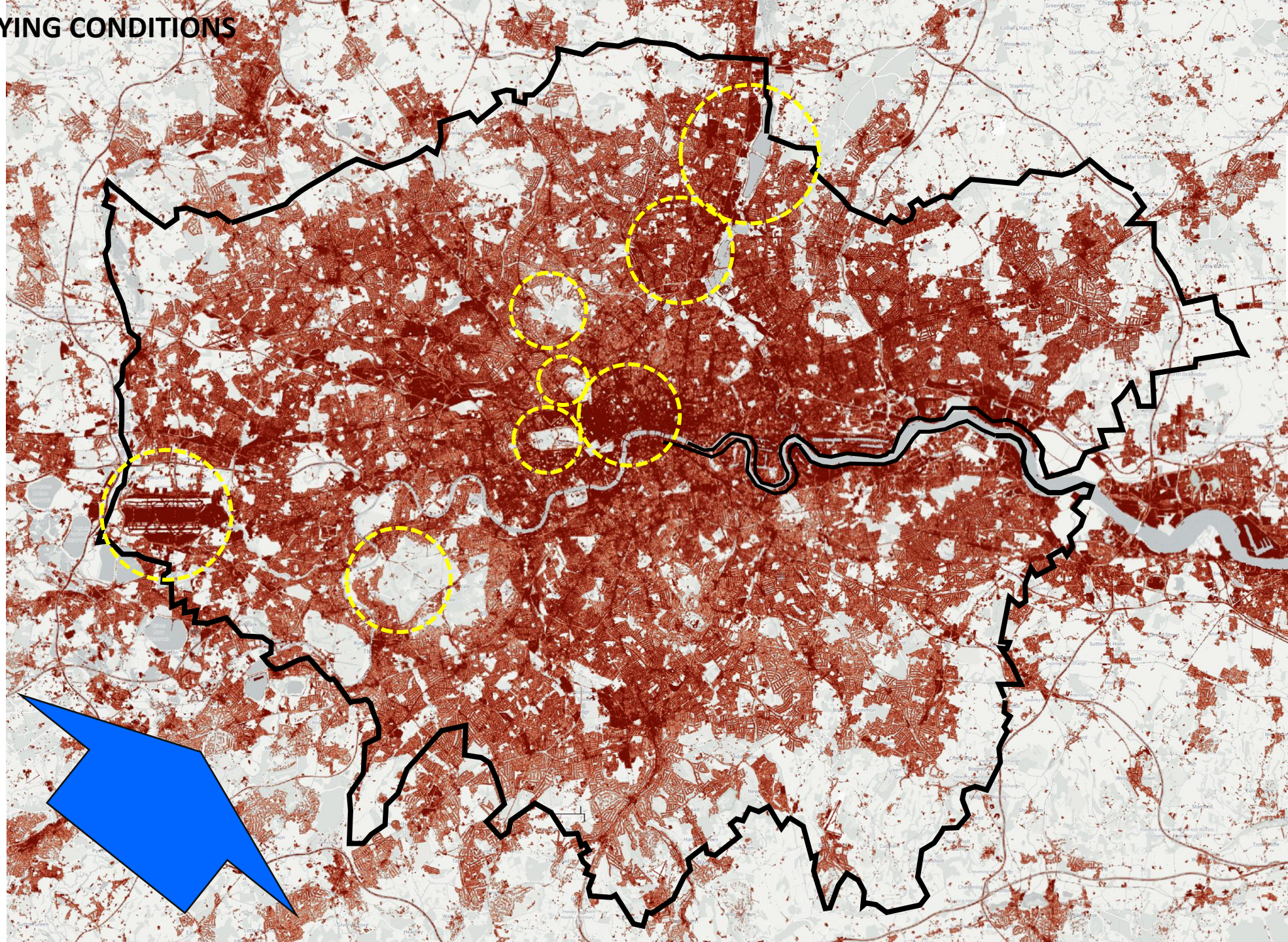


IMPERVIOUS SURFACE [IMP]

1) Fully permeable (e.g., green space)
2) Semi Permeable (e.g., residential)
3) Non permeable (e.g., commercial)



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★ DEPENDENCY ON UNDERLYING CONDITIONS
Camden Town
Dalston
Angel
Whitechapel
City of London
London
Building height (m)
200
150
120
100
75
50
40
20
10
5
0
http://buildingheights.emu-analytics.net
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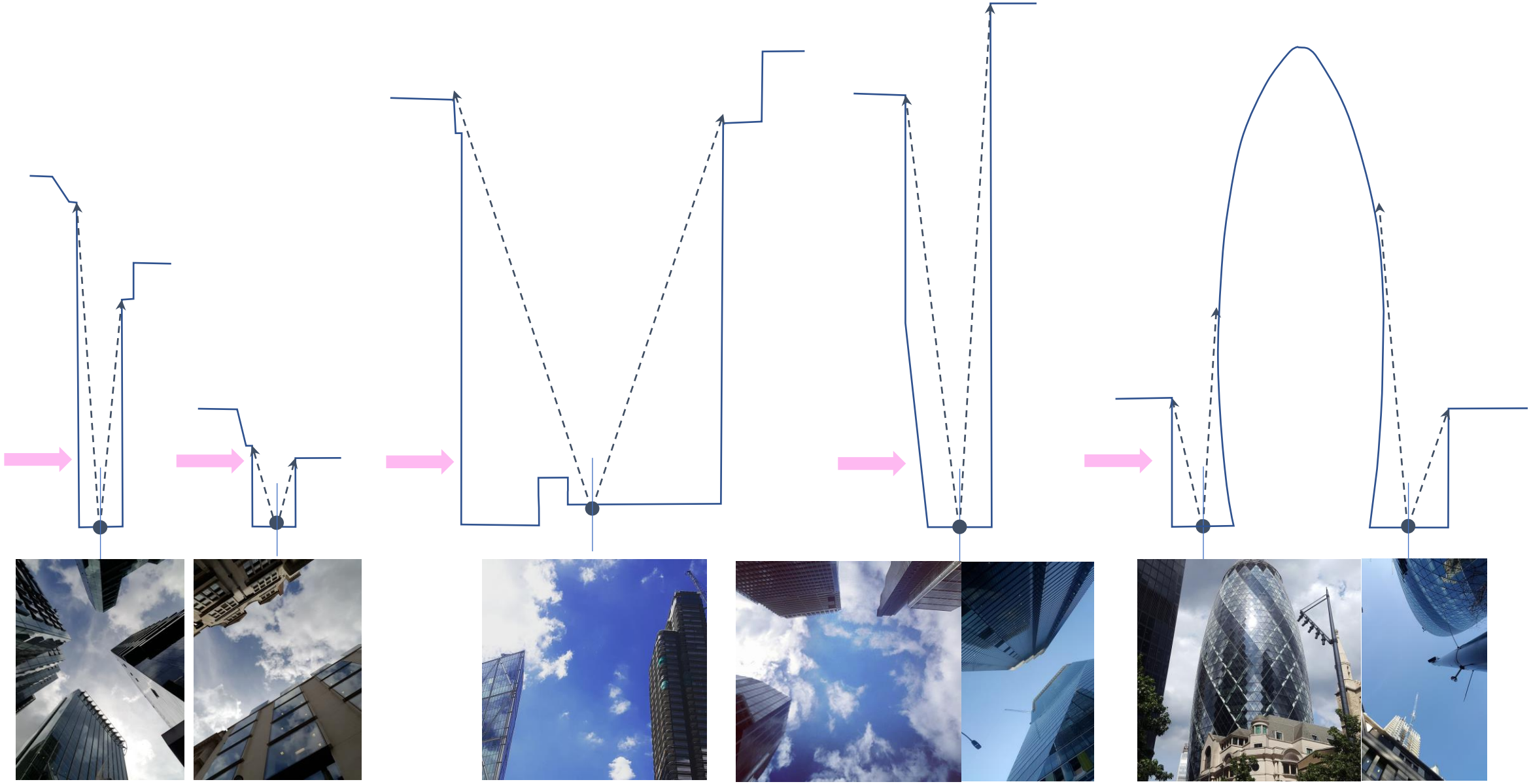
★ EASTERN CLUSTER

★ DEPENDENCY ON UNDERLYING CONDITIONS

★ DIRECT RESULT OF THE FORM AND PROXIMITY OF THE SURFACES TO EACH OTHER

★ City of London Case Study



In the City of London the average height of the building is 25 Meters so what happens when you insert a tall building that protrudes the canopy top?

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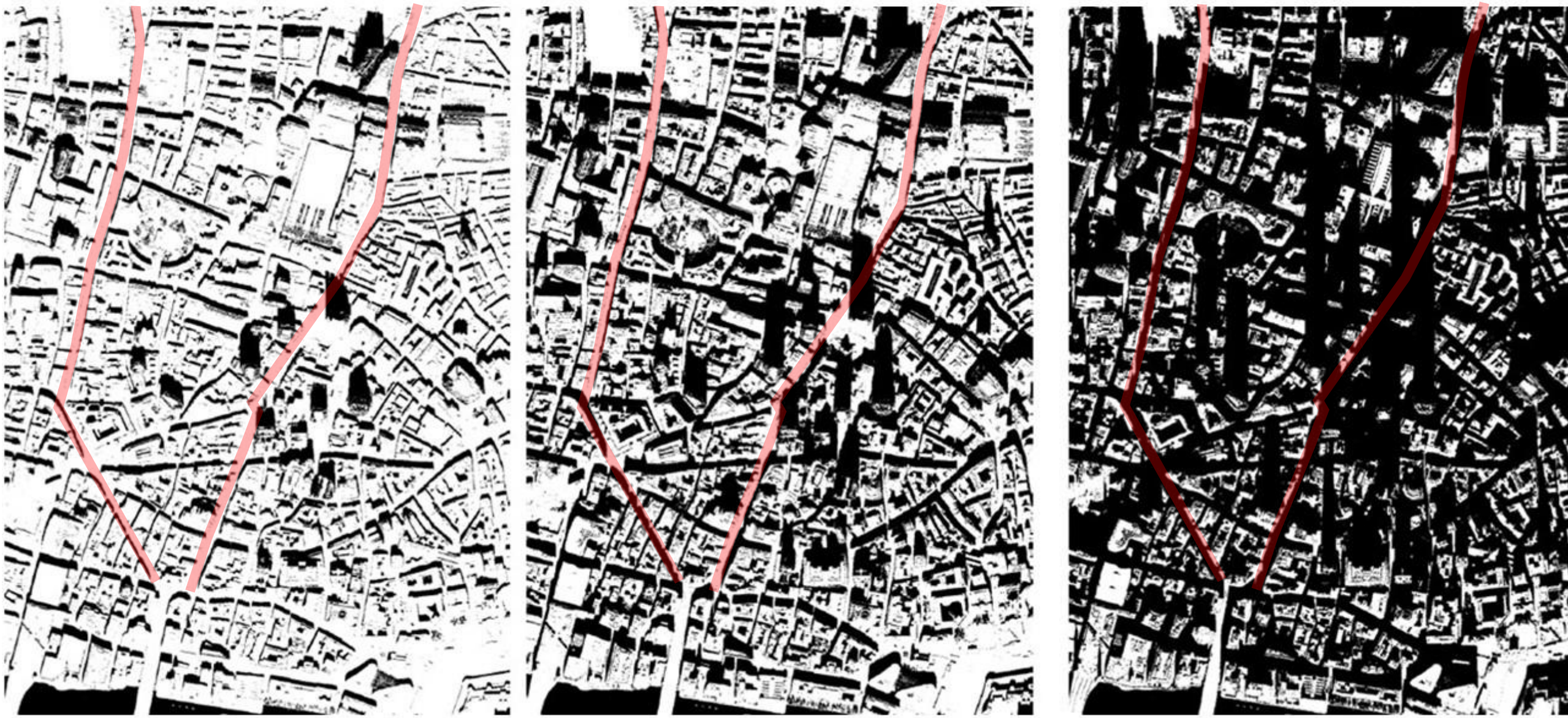
★ Midday Shadow

a) Summer solstice b) Equinox c) Winter Solstice



The overshadowing effect of the tall buildings (Eastern Cluster - City of London) on the roof tops of the lower surrounding buildings. 21st June/Sept/Dec -midday. Source Futcher 2019

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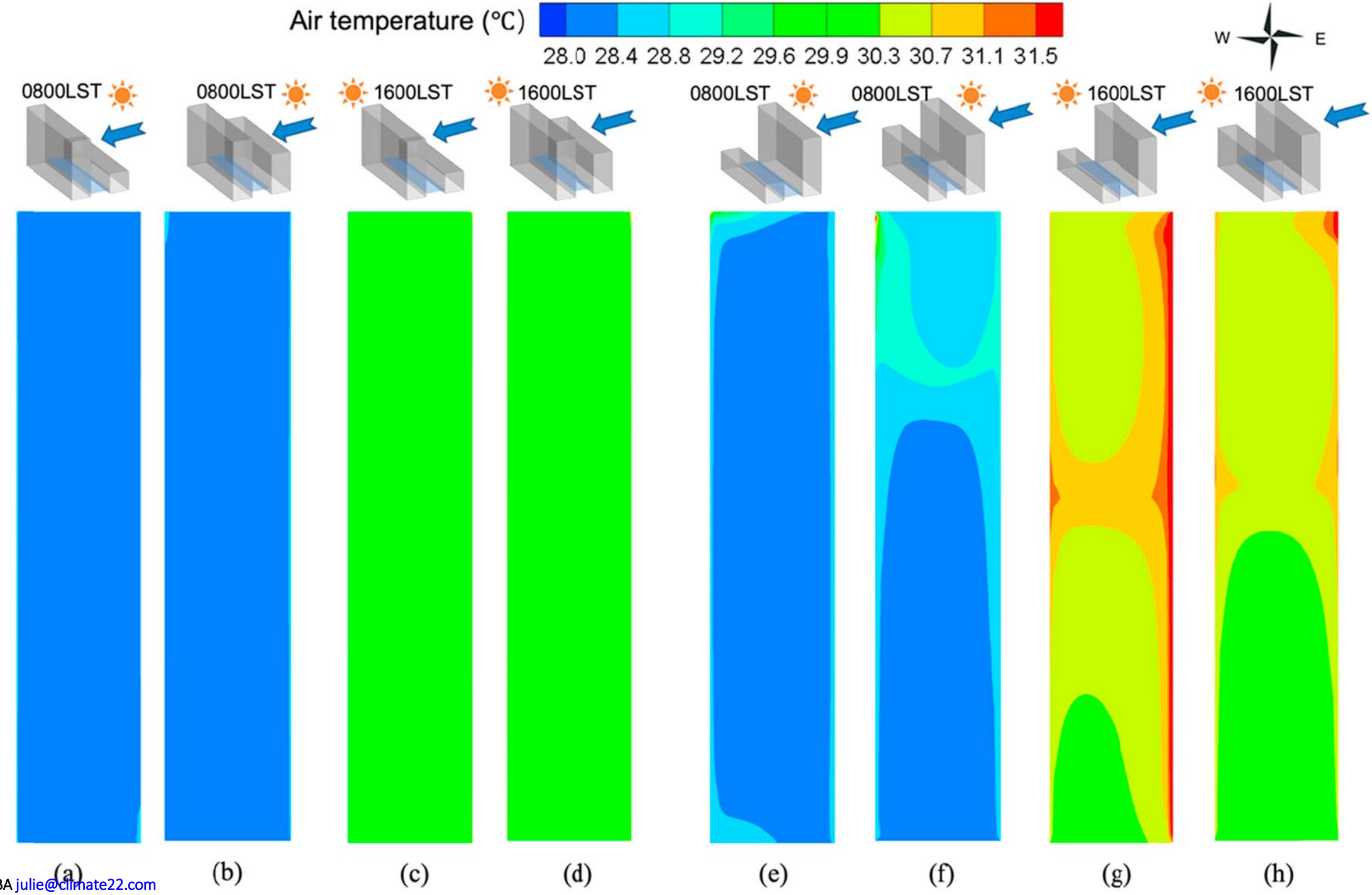

Li Z et al; (2020) Effects of height-asymmetric street canyon configurations on outdoor air temperature and air quality, Building and Environment, Volume 183, 107195, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2020.107195.

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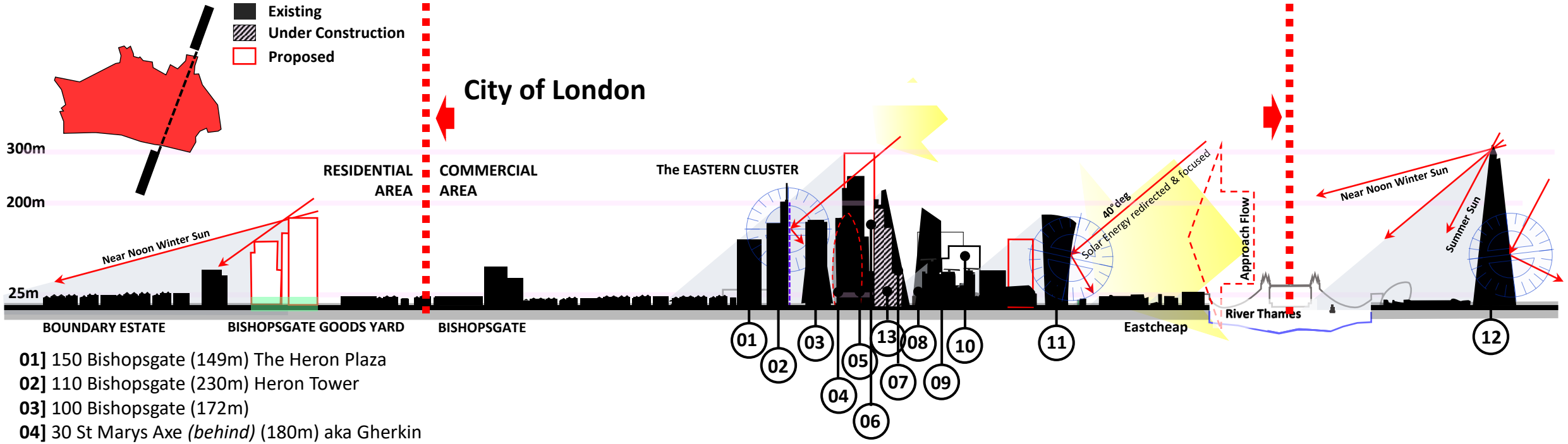
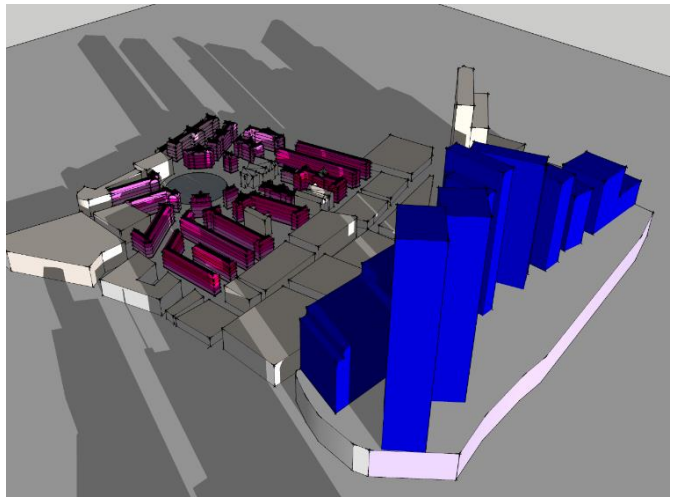
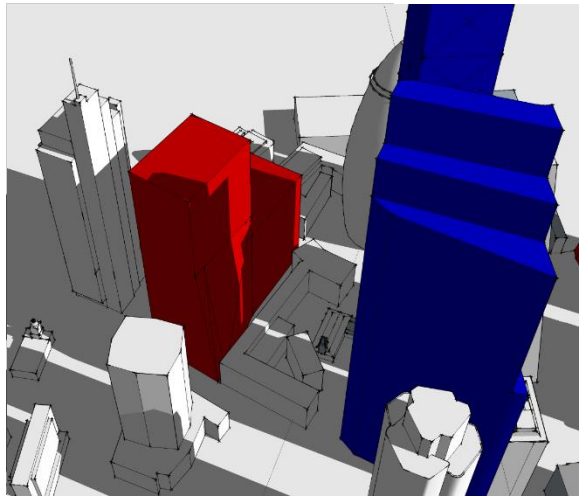
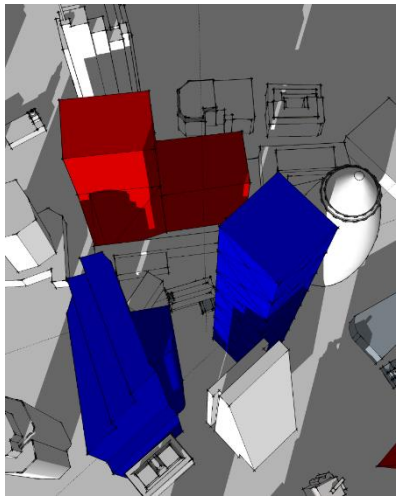
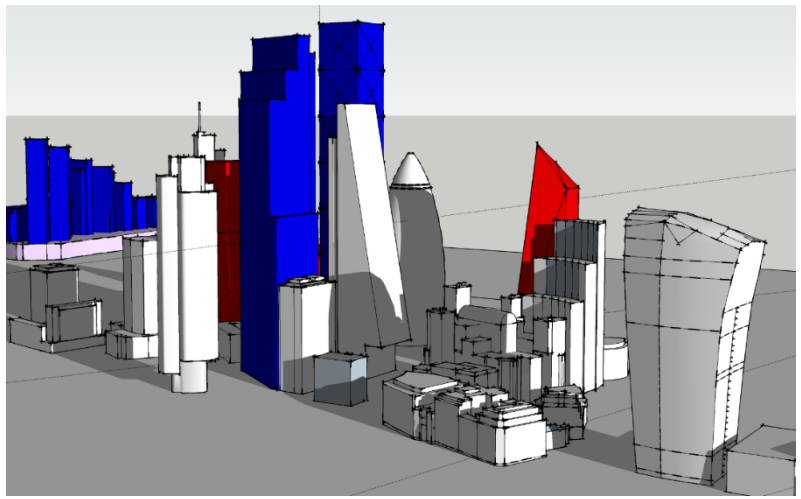


01] 150 Bishopsgate (149m) The Heron Plaza
02] 110 Bishopsgate (230m) Heron Tower
03] 100 Bishopsgate (172m)
04] 30 St Marys Axe *(behind)* (180m) aka Gherkin
05] 22 Bishopsgate (278m) former Pinnacle development
06] No.1 Undershaft *(behind)* (295m)
07] 122 Leadenhall Street (224m) aka the Cheesegrater
08] 52-54 Lime St *(behind)* (192m) The Scalpel
09] 1 Lime St (95m) Lloyds Building
10] 51 Lime St *(behind)* (125m) Willis Building
11] 20 Fenchurch Street (160m) aka Walkie talkie/scorchie
12] 32 London Bridge (310m) The Shard
13] 8 Bishopsgate Tower

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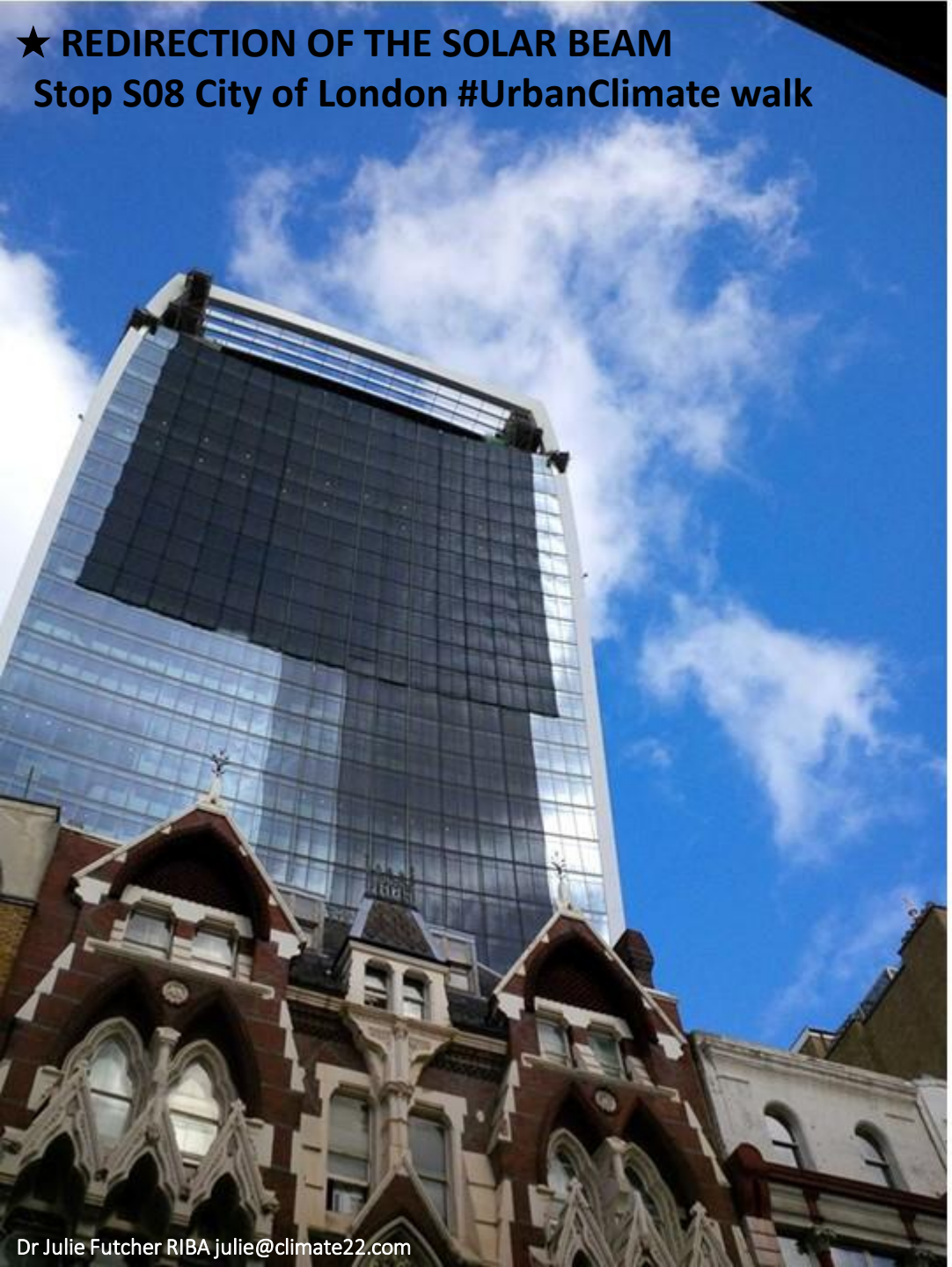
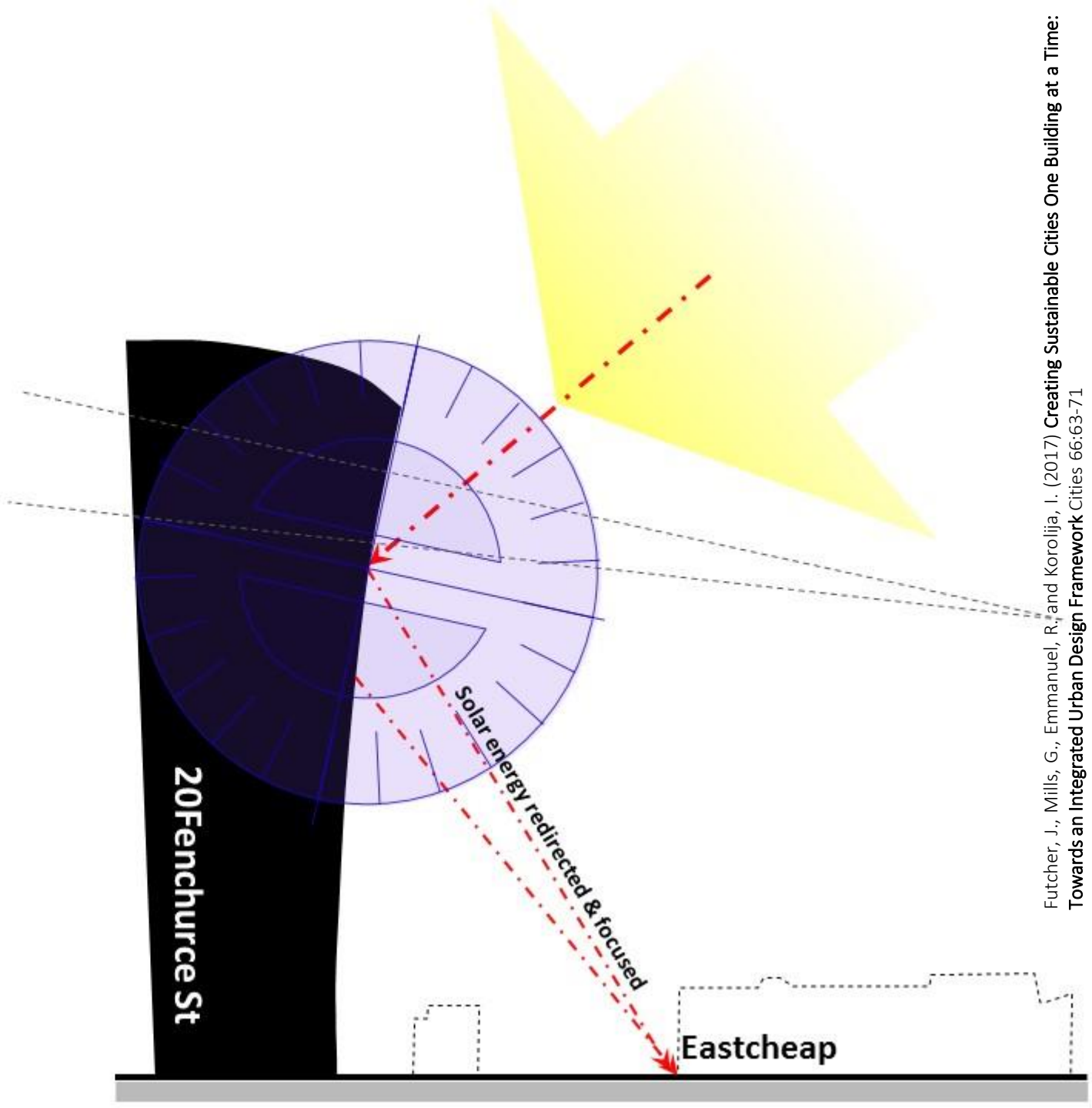
★ REDIRECTION OF THE SOLAR BEAM

Stop S08 City of London #UrbanClimate walk





Futcher, J., Mills, G., Emmanuel, R., and Korolija, I. (2017) **Creating Sustainable Cities One Building at a Time: Towards an Integrated Urban Design Framework** Cities 66:63-71

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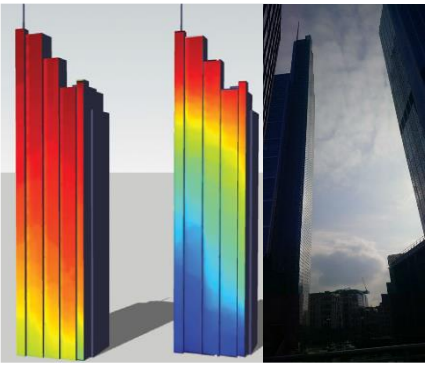
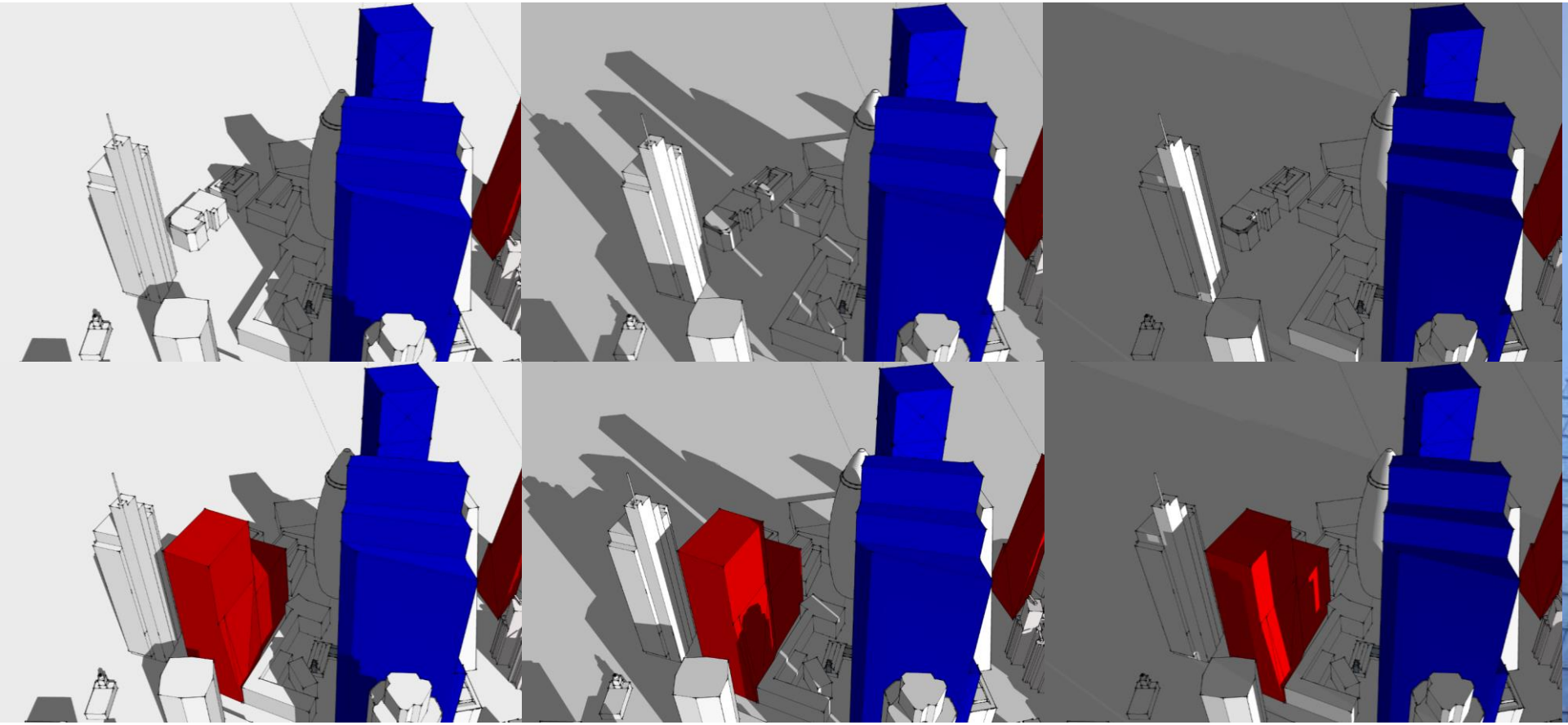
★ ACCESS TO PASSIVE RESOURCES

Stop S06 City of London #UrbanClimate walk



Colour rendering of the Heron Tower's south façade, showing the annual availability of solar/daylight (in lux-hours) before and after the completion of 100 Bishopsgate

June/September/December - mid-afternoon without (top) and with (bottom) 100 Bishopsgate



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7 The Eastern Cluster

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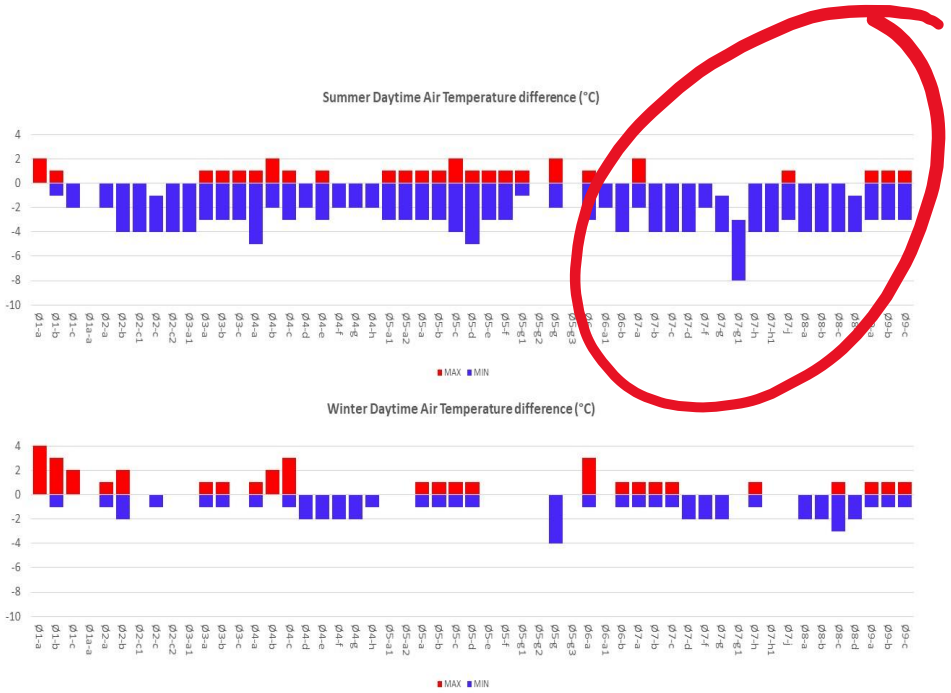
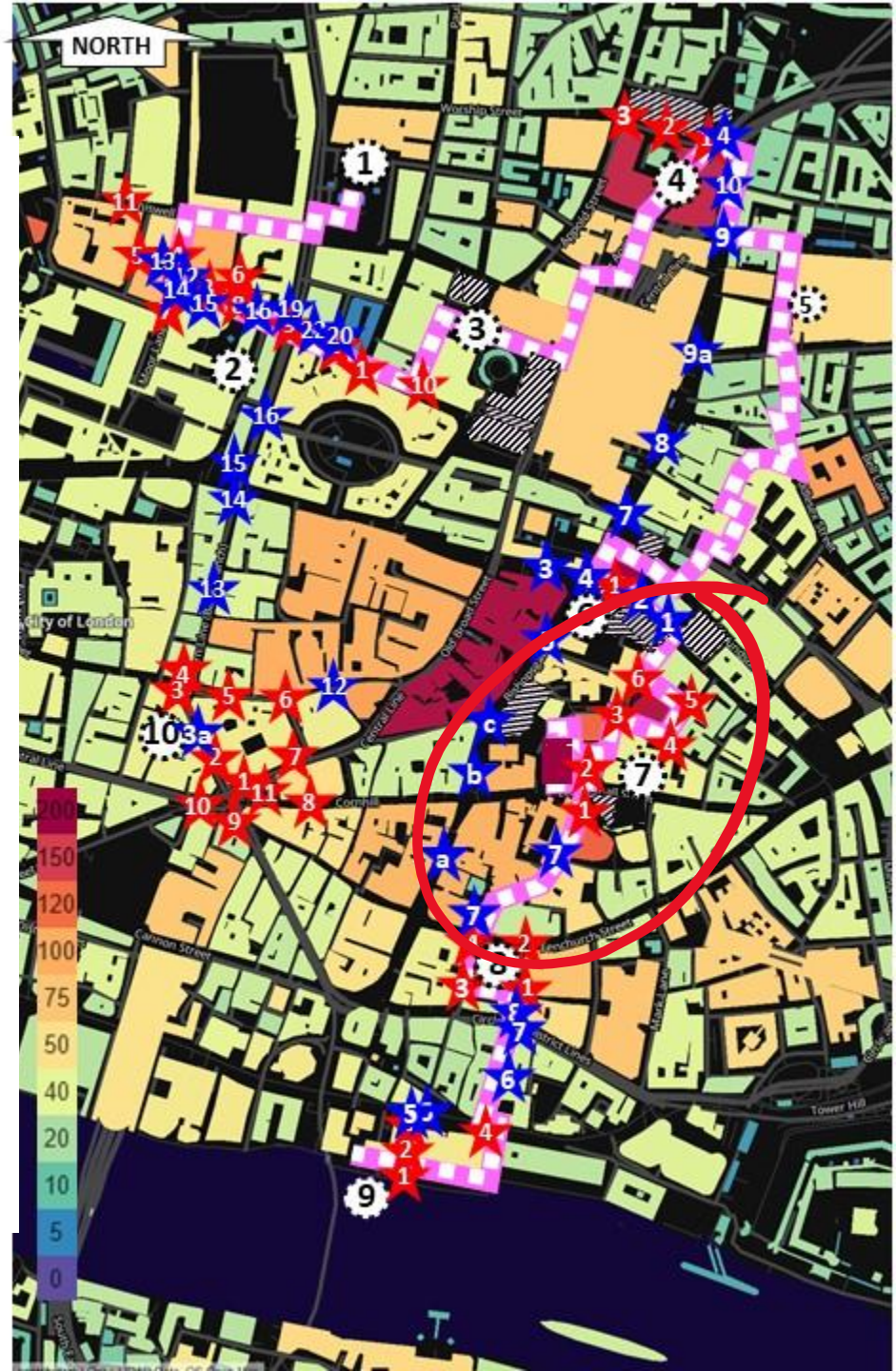
The Role of Urban Built Form on levels of Air Pollution at a Microscale level

A pilot project - City of London / #UrbanLabCity



Site name	number	wind speed (mph) max SUMMER			wind speed (mph) max WINTER		
Eldon Place	a	-1	±	0	0	±	4
Ropemaker	b	1	±	2	8	±	12
Worship Street	So4-g	-1	±	1	-4	±	2
	So4-h	4	±	5	6	±	9
Camomile Street	So6-b	2	±	4	5	±	8
	So6-c	4	±	6	-	-	-
30 St Marys Axe	So7-a	-1	±	3	-2	±	3
	So7-b	1	±	3	1	±	5
	So7-c	-1	±	1	-1	±	4
	So7-d		±	2	0	±	3
The Eastern Cluster	f	3	±	3	6	±	8
	g	5	±	6	2	±	5
		9	±	2	10	-	12
	h	0	±	1	0	±	4
	h_1	0	±	2	-	-	-
	j	0	±	3	-	-	-
20 Fenchurch Street	So8-a	3	±		4	±	5
	8-b	1	±	3	12	±	13
	So8-c		±	-6	4	±	7
	So8-d	1	±	3	1	±	4
The Thames	So9-a	0	±	2	-2	±	2
	So9-b	0	±	3	-2	±	4
	So9-c	0	±	2	-3	±	3



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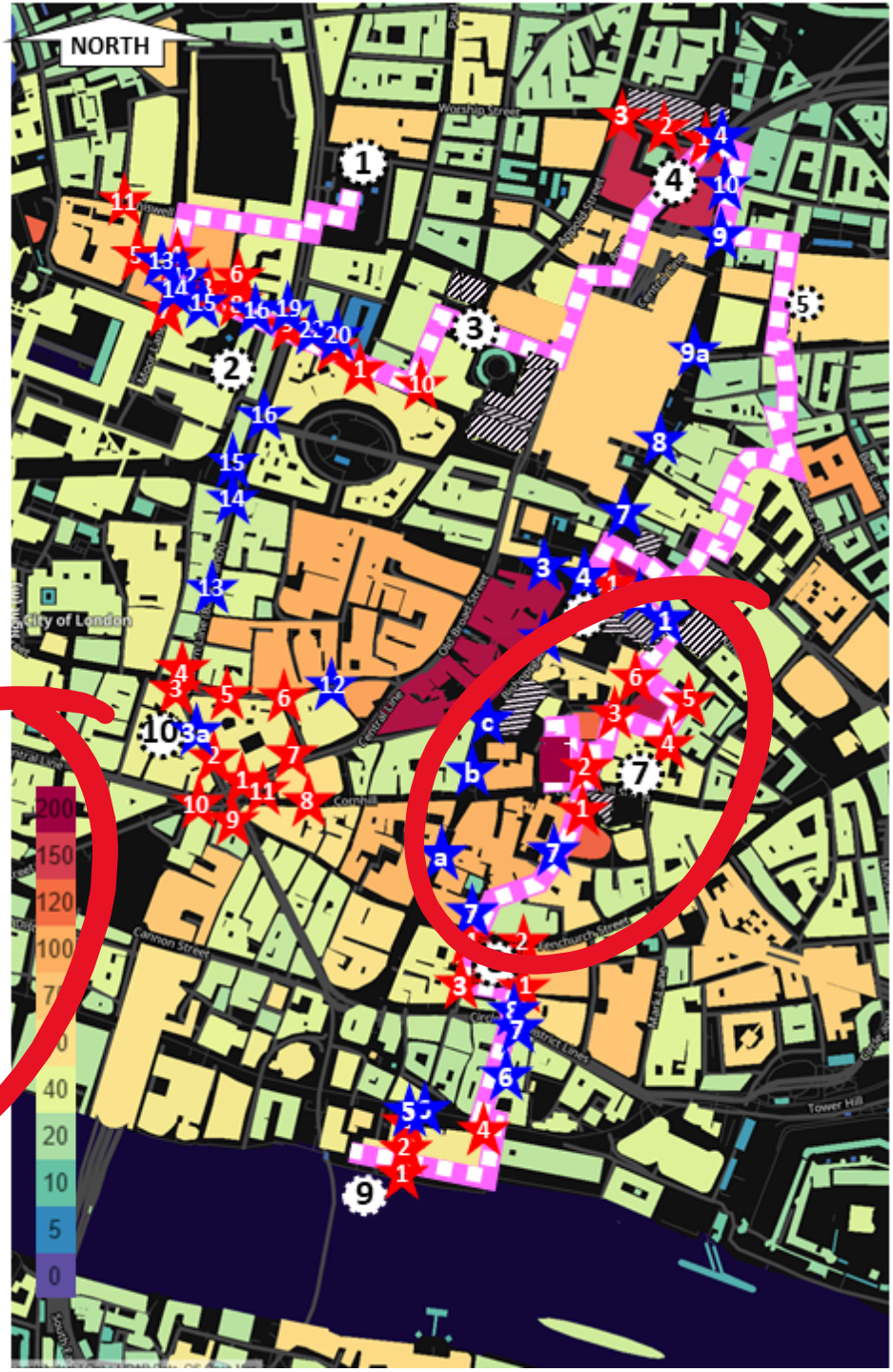
★ City of London Case Study

Site ref		Bias adjusted (0.92) µg/m3
S02-11	BREWERY BEACH ST	51
S02-05	MILTON ST	40
S02-07	MOOR LN (M)	38
S02-04	ROPEMAKER (N)	41
S02-06	ROPEMAKER (W) (N)	40
S02-12	*MOOR LANE*	49
S02-13	*MOOR LANE*	35
S02-14	*ROPEMAKER*	47
S02-16	*CITY POINT*	43
S02-30	*FINSBURY ST (W) (M)*	43
S02-03	ROPEMAKER	55
S02-08	ROPEMAKER (E)	36
S02-09	MOORGATE	71
S02-19	*MOORGATE (N)*	74
S02-20	*SOUTH PLACE (N) (E)*	46
S02-21	*SOUTH PLACE ISLAND*	52
S02-22	*NEAR WILSON ST*	53
S02-02	SOUTH PLACE	50
S02-01	ELDON ST	47
S02-10	ELDON ST OPP NO 15	43
S10-16	*MOORGATE*	56
S10-15	*MOORGATE*	63
S10-14	*MOORGATE 69*	110
S10-13	*MOORGATE*	58
S10-04	MOORGATE (S)	71
S10-03	PRINCES ST (N)	67
S10-03a	*PRINCES ST*	74
S10-02	PRINCES ST (S)	71
S10-01	THREADNEEDLE ST (W)	71
S10-10	MANSION HOUSE (E)	77
S10-09	LOMBARD ST	60
S10-08	OPP 24 CORNHILL	58
S10-11	ROYAL EXCHANGE	56
S10-07	THREADNEEDLE ST (E)	64
S10-05	LOTHBURY (N)	54
S10-06	THROGMORTON (W)	43
S10-12	*THROUGHMORTONS*	39
S04-01	WORSHIP ST	40
S04-02	WORSHIP ST (MID)	43
S04-03	WORSHIP ST (W)	44
S04-04	*WORSHIP ST*	48
S04-10	*TOP OF BISHOPSGATE*	61
S04-09a	*BISHOPSGATE*	60
S04-09	*210 BISHOPSGATE*	58
S04-08	*BISHOPSGATE*	63
S04-07	*LIVERPOOL ST*	78
S07a-01	*JUNCTION (N)*	81
S07a-02	*JUNCTION (W)*	75
S07a-03	*JUNCTION (WW)*	85
S07a-04	*BISHOPSGATE*	78
S07a-05	*BISHOPSGATE (SS)*	75
S06-05	*CAMOMILE ST*	76
S06-01	CAMOMILE ST 100	78
S06-04	*WORMWOOD ST*	66
S06-02	*63 CAMOMILE ST*	58
S06-03	*CAMOMILE ST*	56
S07a-7a	*GRACECHURCH*	72
S07a-7b	*3 BISHOPSGATE*	64
S07a-7c	*BISHOPSGATE*	
S07-06	ST MARY AXE (N)	41
S07-05	BURY ST (N)	40
S07-04	BURY ST (S)	38
S07-03	ST MARY AXE (MID)	40
S07-02	ST MARY AXE (S)	44
S07-01	LIME ST (MID)	31
S07-b	*LIME STREET (2OFC*	32
S07-a	*LIME STREET (EC)*	49
S08-03	PHILPOT LANE (N)	44
S08-02	ROOD LANE	48
S08-04	*PHILPOT LANE (S) (OFC)*	38
S08-01	ROOD LANE	37
S08-08	*EASTCHEAP (N)*	46
S08-07	*EASTCHEAP (S)*	43
S08-06	*ST MARY-AT-HILL*	
S09-06	*MONUMENT ST*	51
S09-05	*LOWER THAMES ST*	63
S09-04	LOWER THAMES ST	61
S09-03	OLD WATERMANS WALK (N)	49
S09-02	OLD WATERMANS WALK (MID)	37
S09-01	OLD WATERMANS WALK (S)	34



Futcher J. and Mills, G. (2020) **'Urban Lab City' Investigating the Role of Built Form on levels of Air Pollution and Urban Climates at Microscale Level** PLEA 2020

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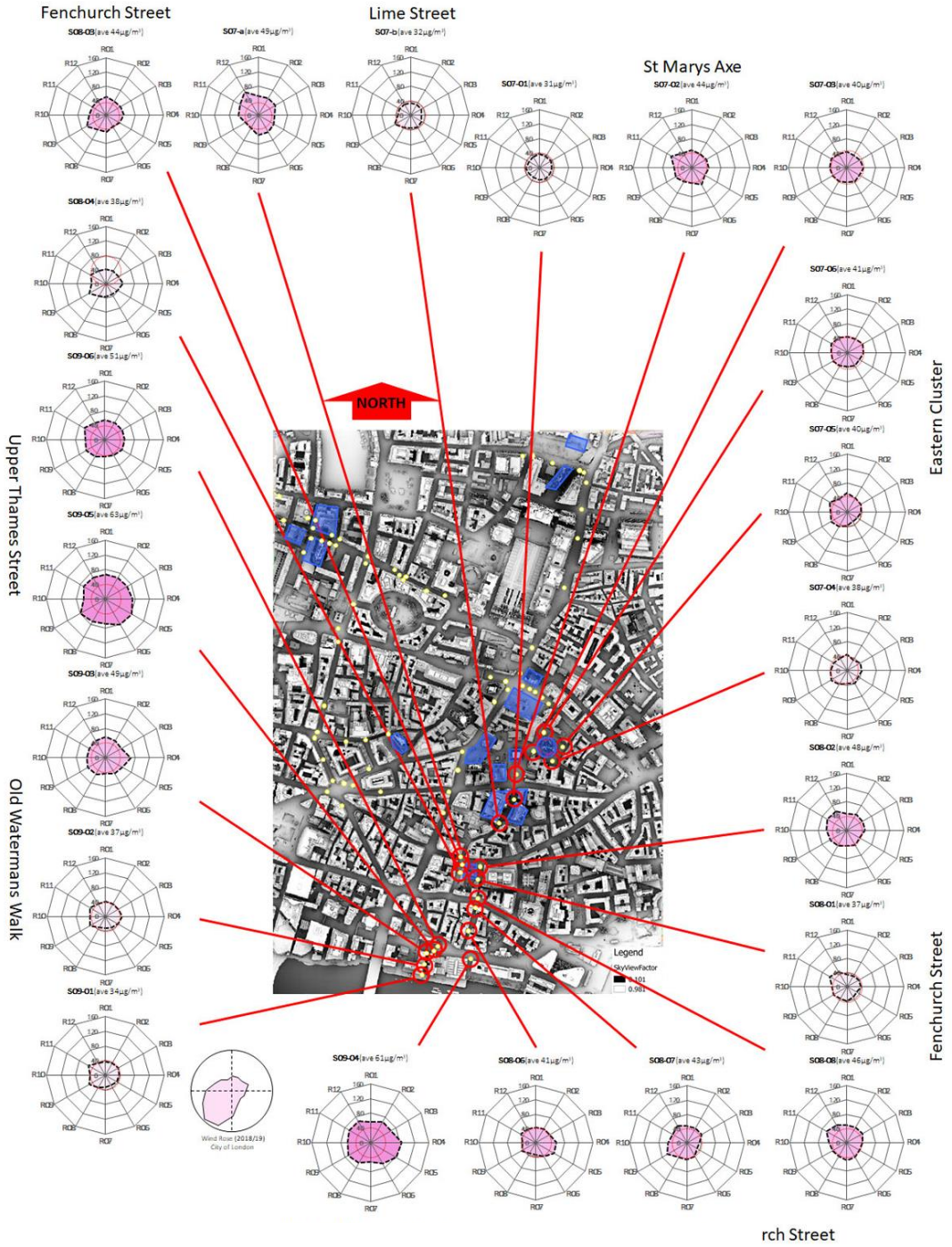

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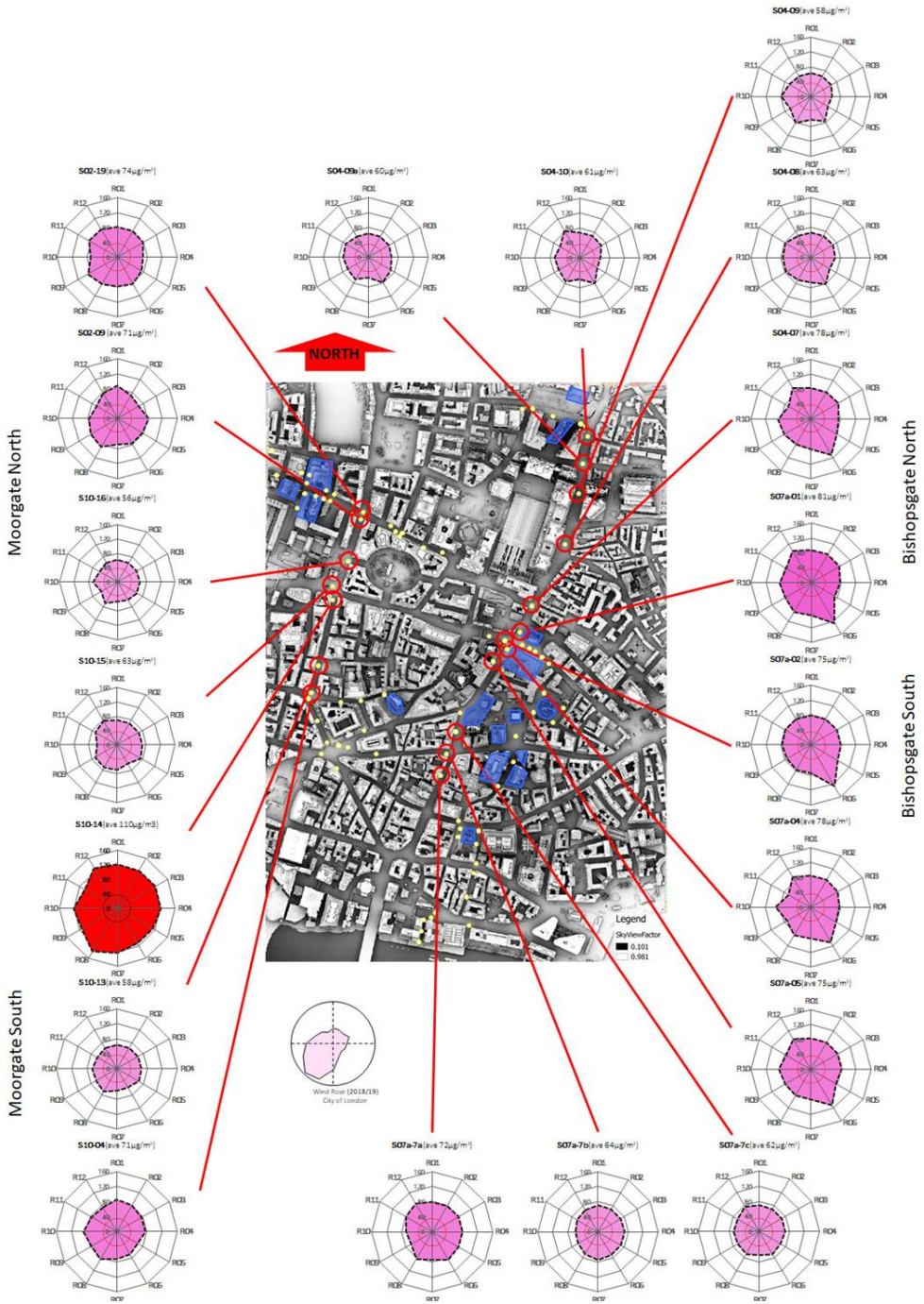
★ Air Quality

parallel to air flow



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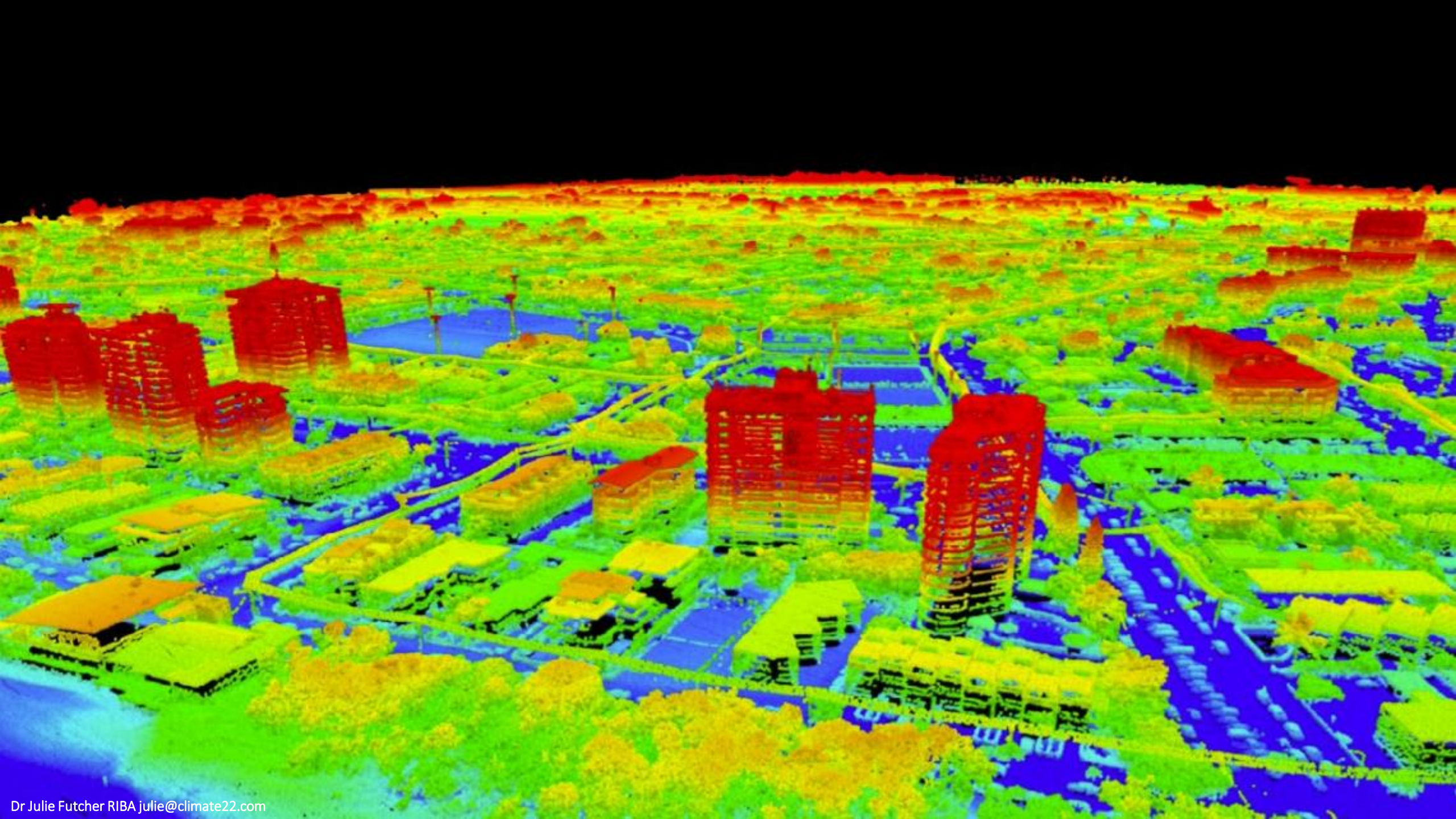

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★ AN OVERSHADOWED SITE

The Boundary Estate showing current (FEBRUARY) levels of solar access into streets

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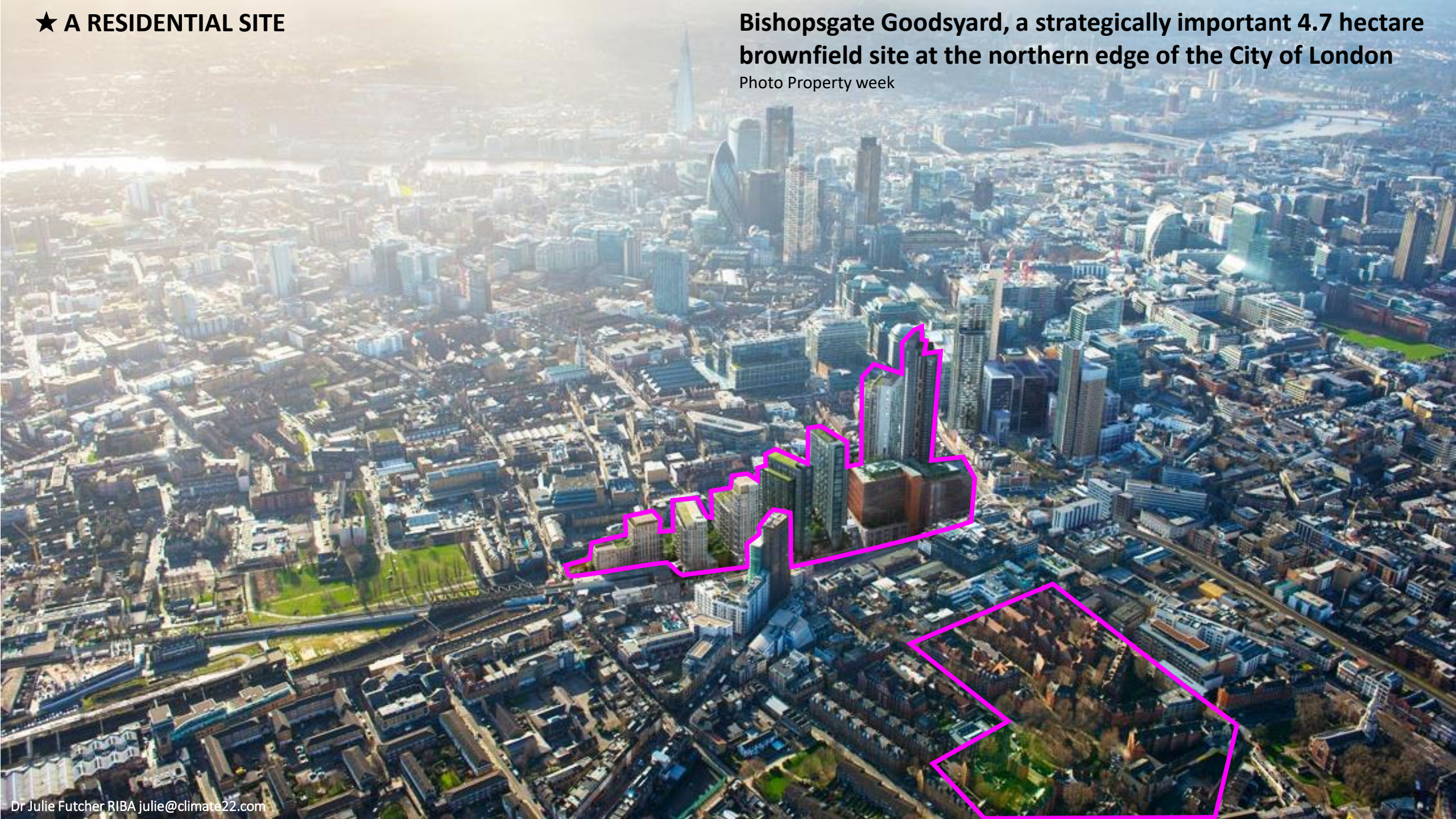
★ A RESIDENTIAL SITE

Bishopsgate Goodsyard, a strategically important 4.7 hectare brownfield site at the northern edge of the City of London

Photo Property week



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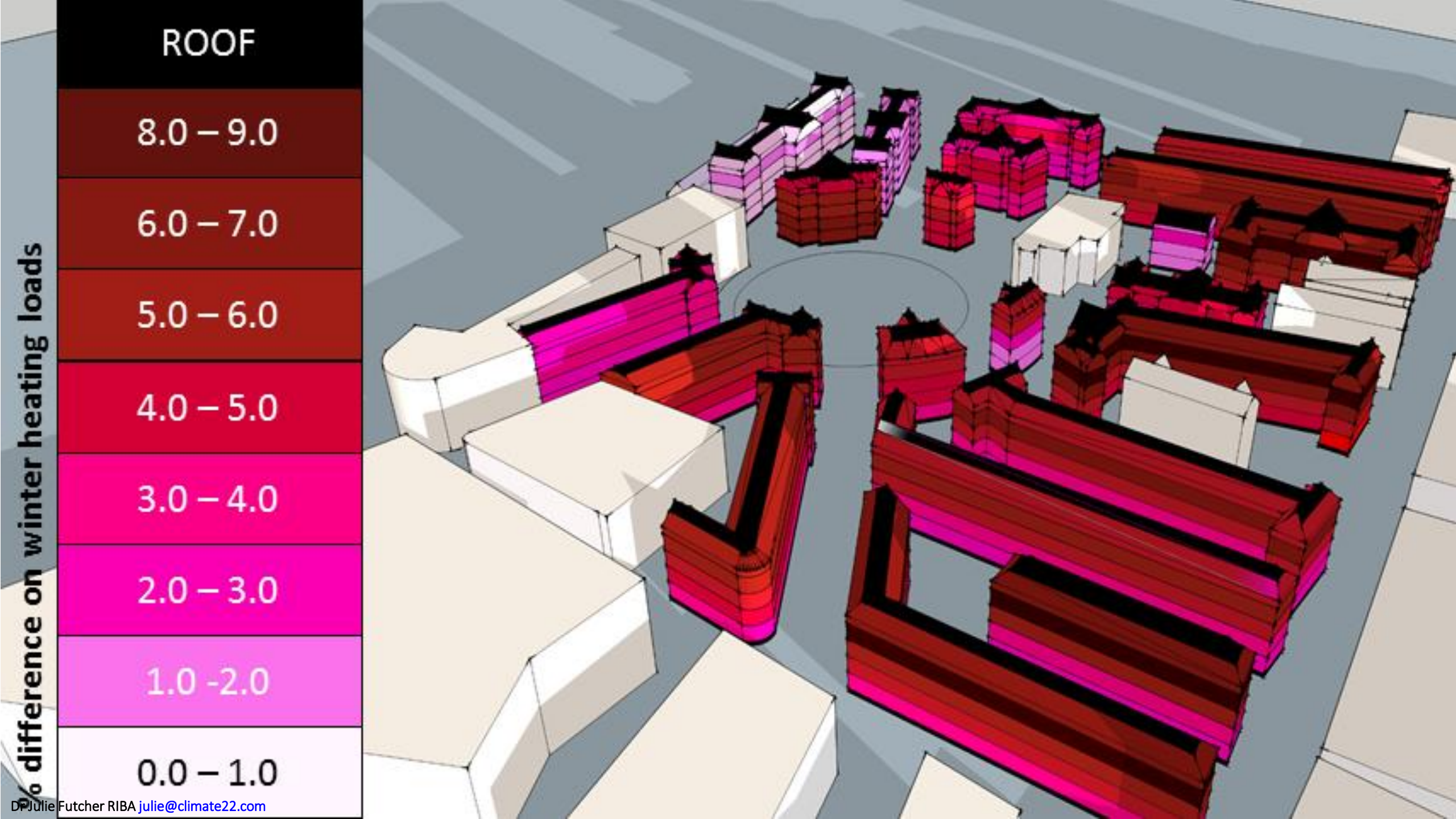

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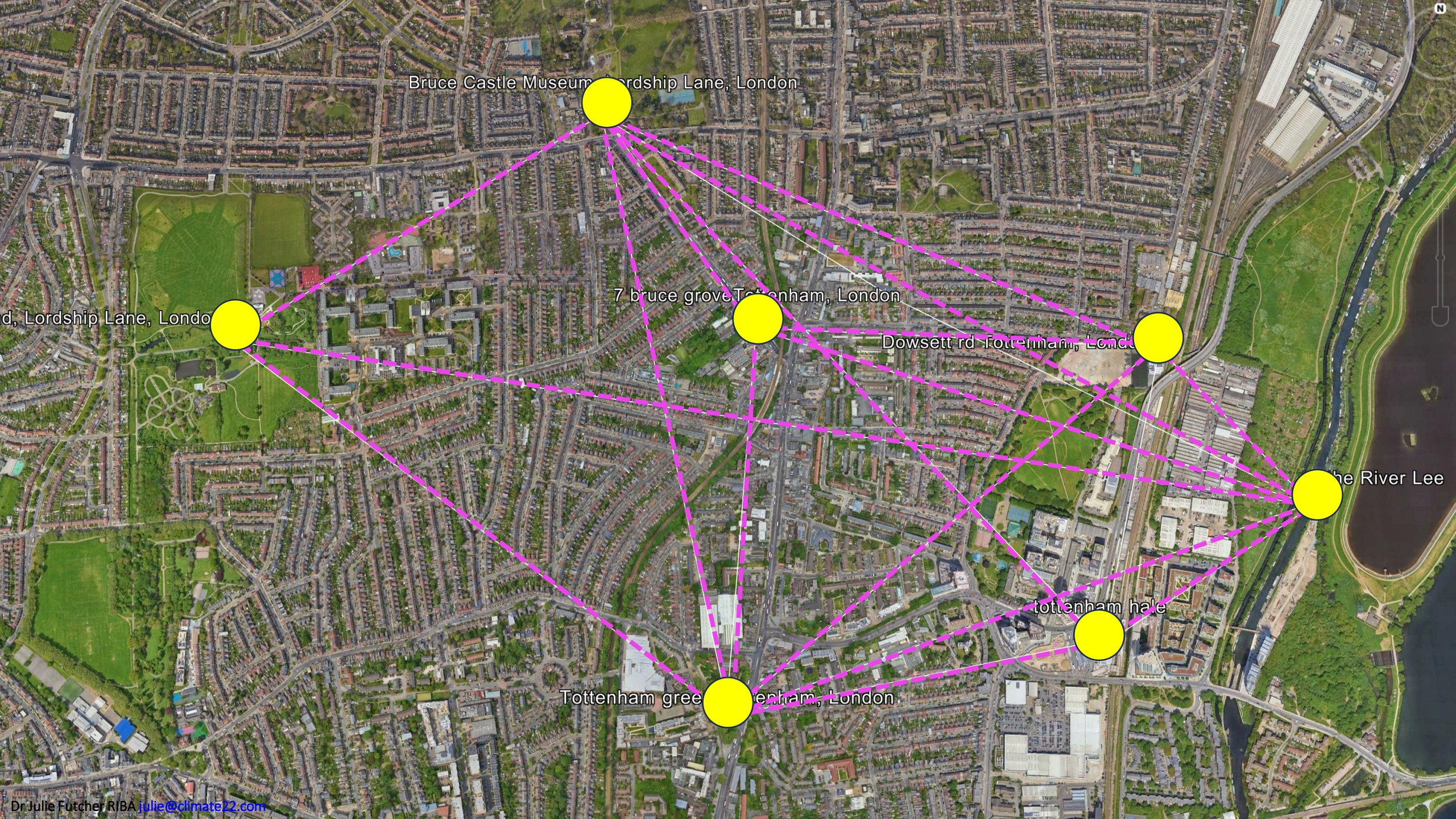

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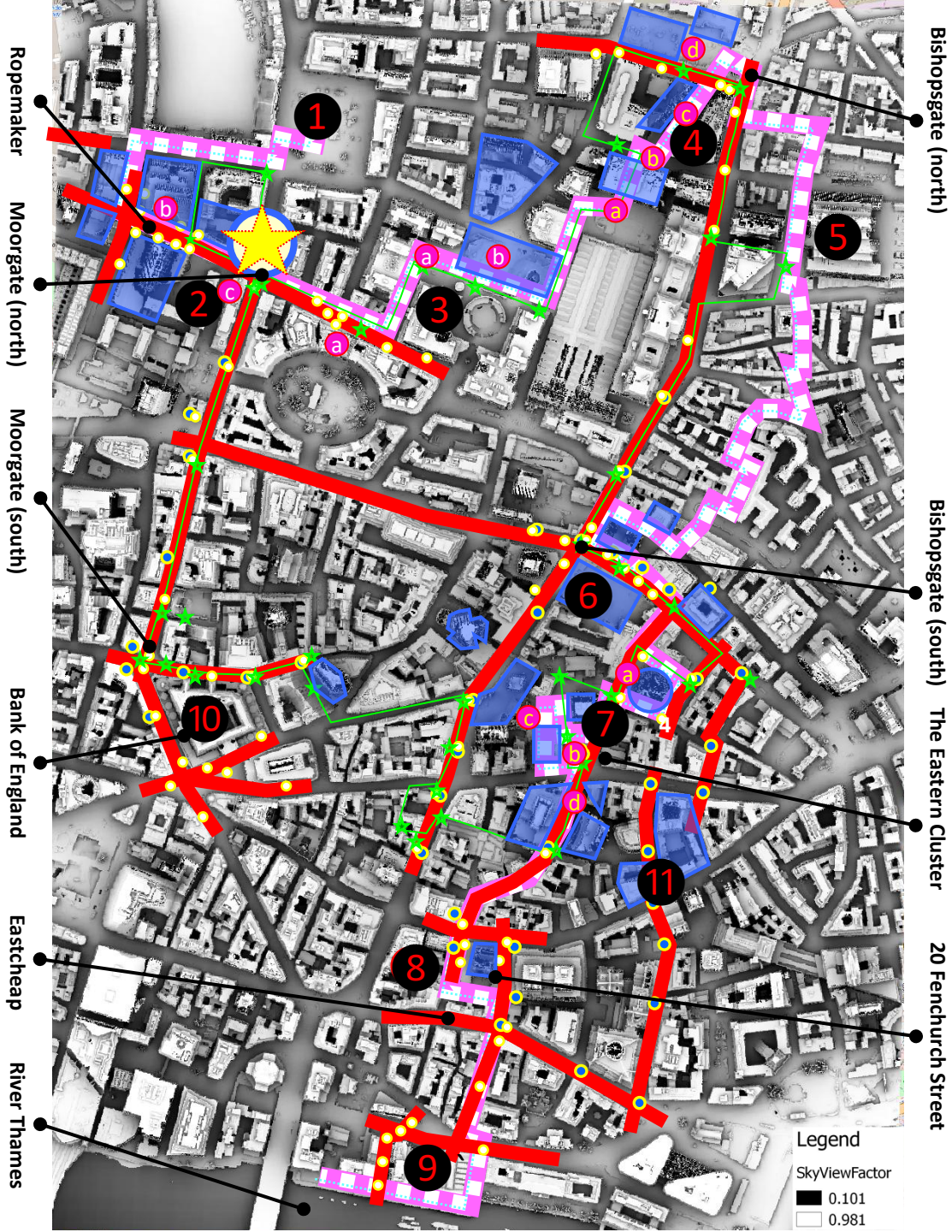
An Urban Climate Walking Tour an instructional technique for linking together diverse aspects of urban sustainability: The City of London



KEY

- An open site
- Intersection
- Street
- BLOCK
- Single Tower
- 2 or more Towers
- Cluster of Towers
- Symmetrical
- Square
- Orientation Ø E/W
- Orientation Ø N/S
- South facing
- Vegetation Good health
- Vegetation Poor health
- Water
- Daytime Function
- Nighttime Function
- Tall Buildings
- Urban Climate Walking Route
- Background Site
- Microclimate & Black Carbon Measurements PART 3
- Areas of Interest
- Microclimate & Nitrogen Dioxide (NO_2) Measurements PART 1 & 2

			Ø	LAYOUT	SYMMETRY	BUILT FORM	H/W	LCZ	GREEN / BLUE INFRASTRUCTURE	FUNCTION (day/night)
1		Finsbury Square	∪		★	□	<0.5	5	☌☌	○
2	b	Ropemaker Place	⧫	⎯		||	9	1	♈	○ ☾
2	c	Upper Moorgate	✚	⎯	★	☰	1	2		○
2	a	Eldon Place	⧫	⎯		☲	2	2		○
3	a	Finsbury Avenue Sq.	∪	□		☲	1	2	☌	○
3	b	5 Broadgate	⇊	□		☳	1	1	♈	○
4	a	Exchange House	⇊	□		☲	1	2	☌⧫	○
4	b	Broadgate Tower	⇊	□		|	2	1	♈	○
4	c	Worship Street	⧫	⎯	★	|	3	1		
4	d	Principle place	∪	□		|	4	1	☌	☾
5		Bishops Square (Spitalfields)	⬲	⎯		☰	1	2	☌☌⧫	○
6		110 & 100 Bishopsgate	⧫	✚		||	7	2		○ ☾
7	a	30 St Marys Axe	□			|||	3	1	☌	○
7	b	St Helens Square	□			|||	8	1	☌	○
7	c	Undershaft	□			|||	8	1		○
7	d	Lime Street	□			|||	8	1		○
8		20 Fenchurch Street	⇊	⎯		|	5	2	☌♈	○
9		Thames Path; London Bridge	⇊			∪		G	⧫	
10		Bank | Lower Moorgate	□	✚			1	2		○

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