Cooling Effects of Blue and Green Infrastructure on Urban Microclimate

A Case Study at Thu Duc District, Ho Chi Minh City

Le Thi Kieu, Stefan Schäfer

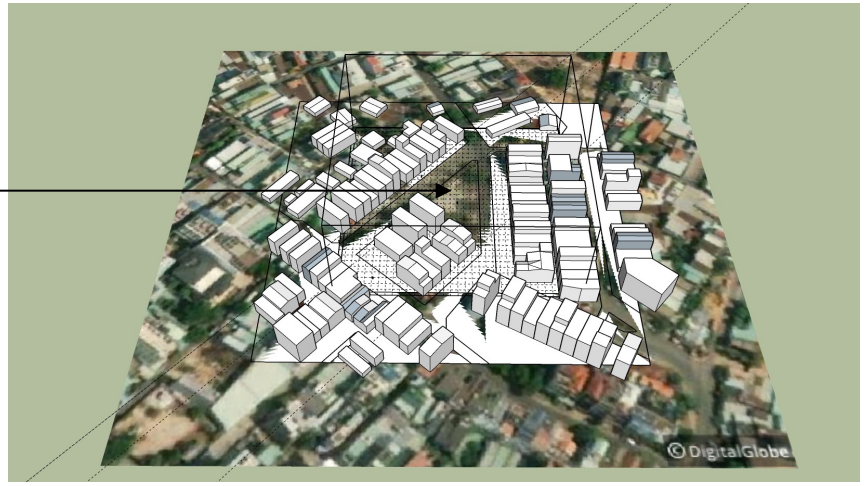
TECHNISCHE UNIVERSITÄT DARMSTADT

Overall information

Study site and scenarios

- Location: A residential area in a developed urban area in Ho Chi Minh City
- Site dimension: 100m x 100m
- Scenarios
  - Baseline model
  - Measure 1: Green roof (only on buildings with flat roofs) and green wall
  - Measure 2: Water fountain in the pocket park (diameter: 10m, height: 4m)

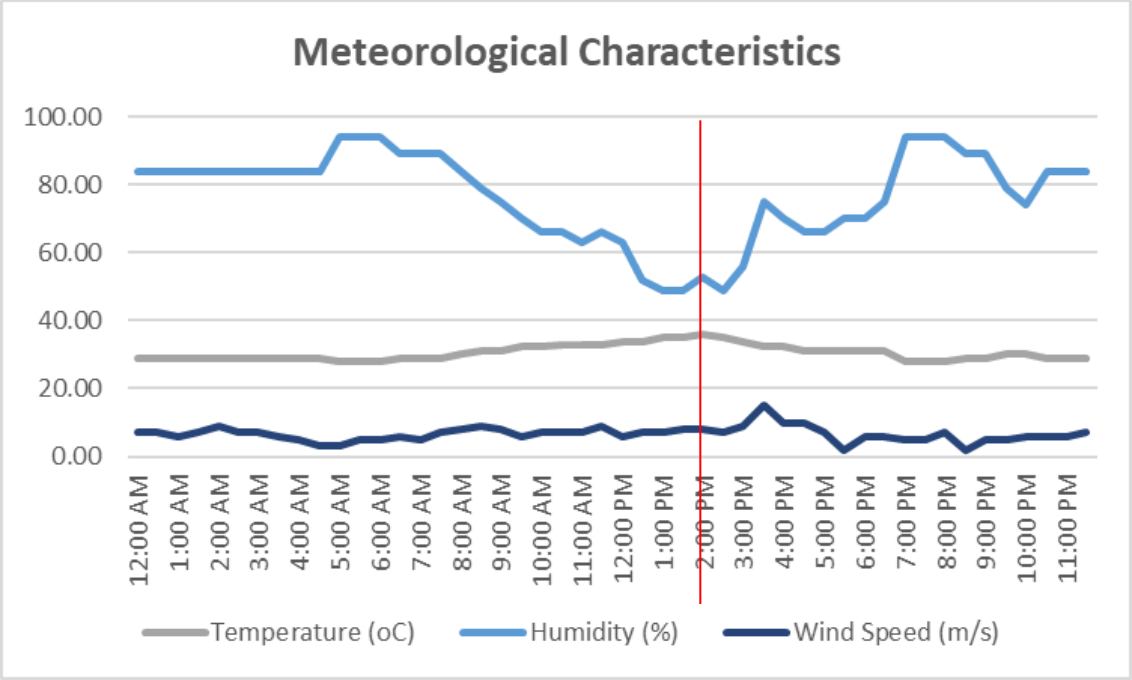
Site location on map



Overall information

Time settings

- Date and time for the thermodynamic simulation
  - 15.05.2022: The hottest day in the dry season (a.k.a. the hottest day in the year)
  - Whole day and especially at 14:00 when having the highest air temperature and the lowest humidity



Overall information

Microclimatic variables

TECHNISCHE UNIVERSITÄT DARMSTADT

"Microclimate is the suite of climatic conditions measured in localized areas near the earth's surface. These environmental variables - which include **temperature, light, wind speed, and moisture**—provide meaningful indicators for habitat selection and other ecological activities". (Source: https://doi.org/10.1016/B978-012663315-3/50006-X)

Selected variables:

- (Potential) air temperature
- Relative humidity

NOAA national weather service: heat index

Temperature / Relative humidity	80 °F (27 °C)	82 °F (28 °C)	84 °F (29 °C)	86 °F (30 °C)	88 °F (31 °C)	90 °F (32 °C)	92 °F (33 °C)	94 °F (34 °C)	96 °F (36 °C)	98 °F (37 °C)	100 °F (38 °C)	102 °F (39 °C)	104 °F (40 °C)	106 °F (41 °C)	108 °F (42 °C)	110 °F (43 °C)
40%	80 °F (27 °C)	81 °F (27 °C)	83 °F (28 °C)	85 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	94 °F (34 °C)	97 °F (36 °C)	101 °F (38 °C)	105 °F (41 °C)	109 °F (43 °C)	114 °F (46 °C)	119 °F (48 °C)	124 °F (51 °C)	130 °F (54 °C)	136 °F (58 °C)
45%	80 °F (27 °C)	82 °F (28 °C)	84 °F (29 °C)	87 °F (31 °C)	89 °F (32 °C)	93 °F (34 °C)	96 °F (36 °C)	100 °F (38 °C)	104 °F (40 °C)	109 °F (43 °C)	114 °F (46 °C)	119 °F (48 °C)	124 °F (51 °C)	130 °F (54 °C)	137 °F (58 °C)	
50%	81 °F (27 °C)	83 °F (28 °C)	85 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	95 °F (35 °C)	99 °F (37 °C)	103 °F (39 °C)	108 °F (42 °C)	113 °F (45 °C)	118 °F (48 °C)	124 °F (51 °C)	131 °F (55 °C)	137 °F (58 °C)		
55%	81 °F (27 °C)	84 °F (29 °C)	86 °F (30 °C)	89 °F (32 °C)	93 °F (34 °C)	97 °F (36 °C)	101 °F (38 °C)	106 °F (41 °C)	112 °F (44 °C)	117 °F (47 °C)	124 °F (51 °C)	130 °F (54 °C)	137 °F (58 °C)			
60%	82 °F (28 °C)	84 °F (29 °C)	88 °F (31 °C)	91 °F (33 °C)	95 °F (35 °C)	100 °F (38 °C)	105 °F (41 °C)	110 °F (43 °C)	116 °F (47 °C)	123 °F (51 °C)	129 °F (54 °C)	137 °F (58 °C)				
65%	82 °F (28 °C)	85 °F (29 °C)	89 °F (32 °C)	93 °F (34 °C)	98 °F (37 °C)	103 °F (39 °C)	108 °F (42 °C)	114 °F (46 °C)	121 °F (49 °C)	128 °F (53 °C)	136 °F (58 °C)					
70%	83 °F (28 °C)	86 °F (30 °C)	90 °F (32 °C)	95 °F (35 °C)	100 °F (38 °C)	105 °F (41 °C)	112 °F (44 °C)	119 °F (48 °C)	126 °F (52 °C)	134 °F (57 °C)						
75%	84 °F (29 °C)	88 °F (31 °C)	92 °F (33 °C)	97 °F (36 °C)	103 °F (39 °C)	109 °F (43 °C)	116 °F (47 °C)	124 °F (51 °C)	132 °F (56 °C)							
80%	84 °F (29 °C)	89 °F (32 °C)	94 °F (34 °C)	100 °F (38 °C)	106 °F (41 °C)	113 °F (45 °C)	121 °F (49 °C)	129 °F (54 °C)								
85%	85 °F (29 °C)	90 °F (32 °C)	96 °F (36 °C)	102 °F (39 °C)	110 °F (43 °C)	117 °F (47 °C)	126 °F (52 °C)	135 °F (57 °C)								
90%	86 °F (30 °C)	91 °F (33 °C)	98 °F (37 °C)	105 °F (41 °C)	113 °F (45 °C)	122 °F (50 °C)	131 °F (55 °C)									
95%	86 °F (30 °C)	93 °F (34 °C)	100 °F (38 °C)	108 °F (42 °C)	117 °F (47 °C)	127 °F (53 °C)										
100%	87 °F (31 °C)	95 °F (35 °C)	103 °F (39 °C)	112 °F (44 °C)	121 °F (49 °C)	132 °F (56 °C)										

Key to colors: Caution; Extreme caution; Danger; Extreme danger

Source: https://bigladdersoftware.com/epx/docs/9-6/engineering-reference/resilience-metrics.html

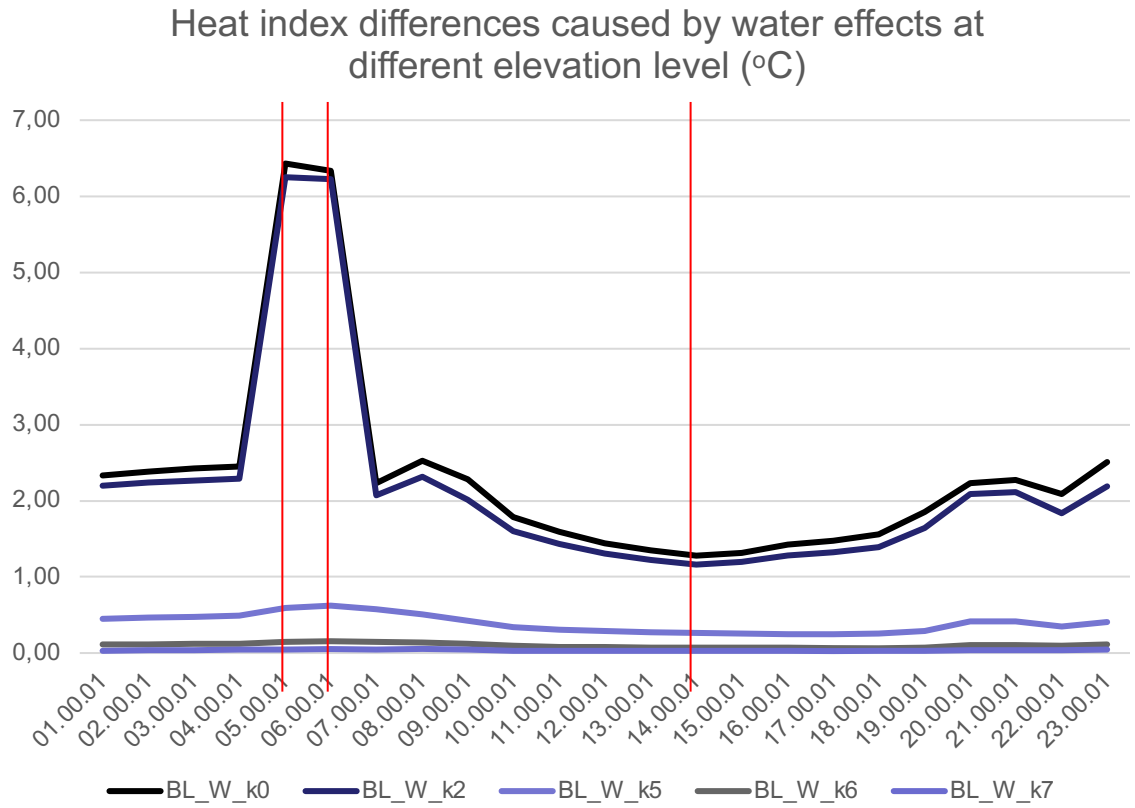
Heat Index in Celsius	Heat Index Level
Less than 26.7 °C	Safe: no risk of heat hazard
26.7 °C - 32.2 °C	Caution: fatigue is possible with prolonged exposure and activity. Continuing activity could result in heat cramps.
32.2 °C - 39.4 °C	Extreme caution: heat cramps and heat exhaustion are possible. Continuing activity could result in heat stroke.
39.4 °C - 51.7 °C	Danger: heat cramps and heat exhaustion are likely; heat stroke is probable with continued activity.
over 51.7 °C	Extreme danger: heat stroke is imminent.

Overall information

Elevation levels

Blue infrastructure

Measured at 16:00, different levels – Cooling effects of water

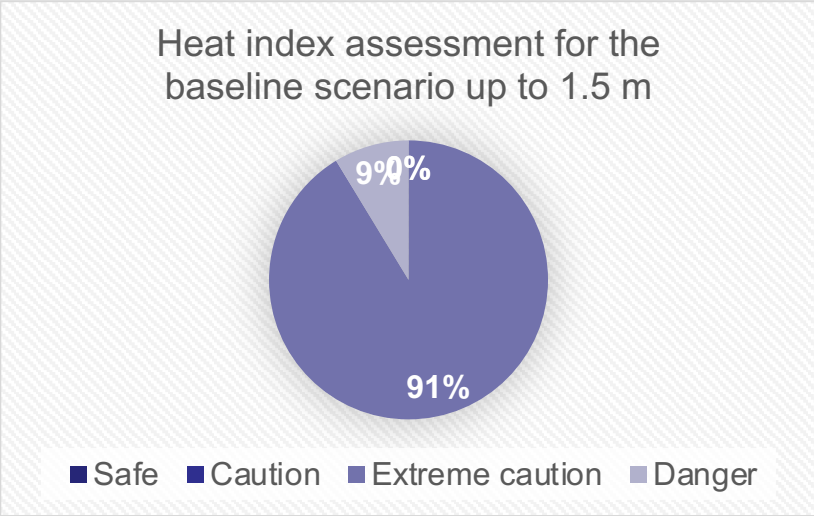


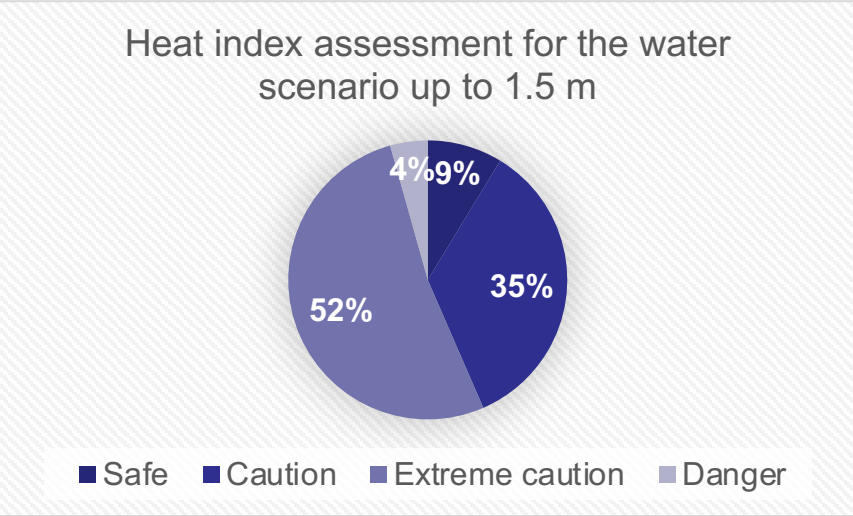
Max.: 6.42 °C
Min: 0.03 °C
Median: 0.41 °C
Average: 1.00 °C

The cooling effects of the water fountain (10 m high) mostly take place at the lower elevation levels.

Blue infrastructure

Measured at 16:00, different levels – Cooling effects of water

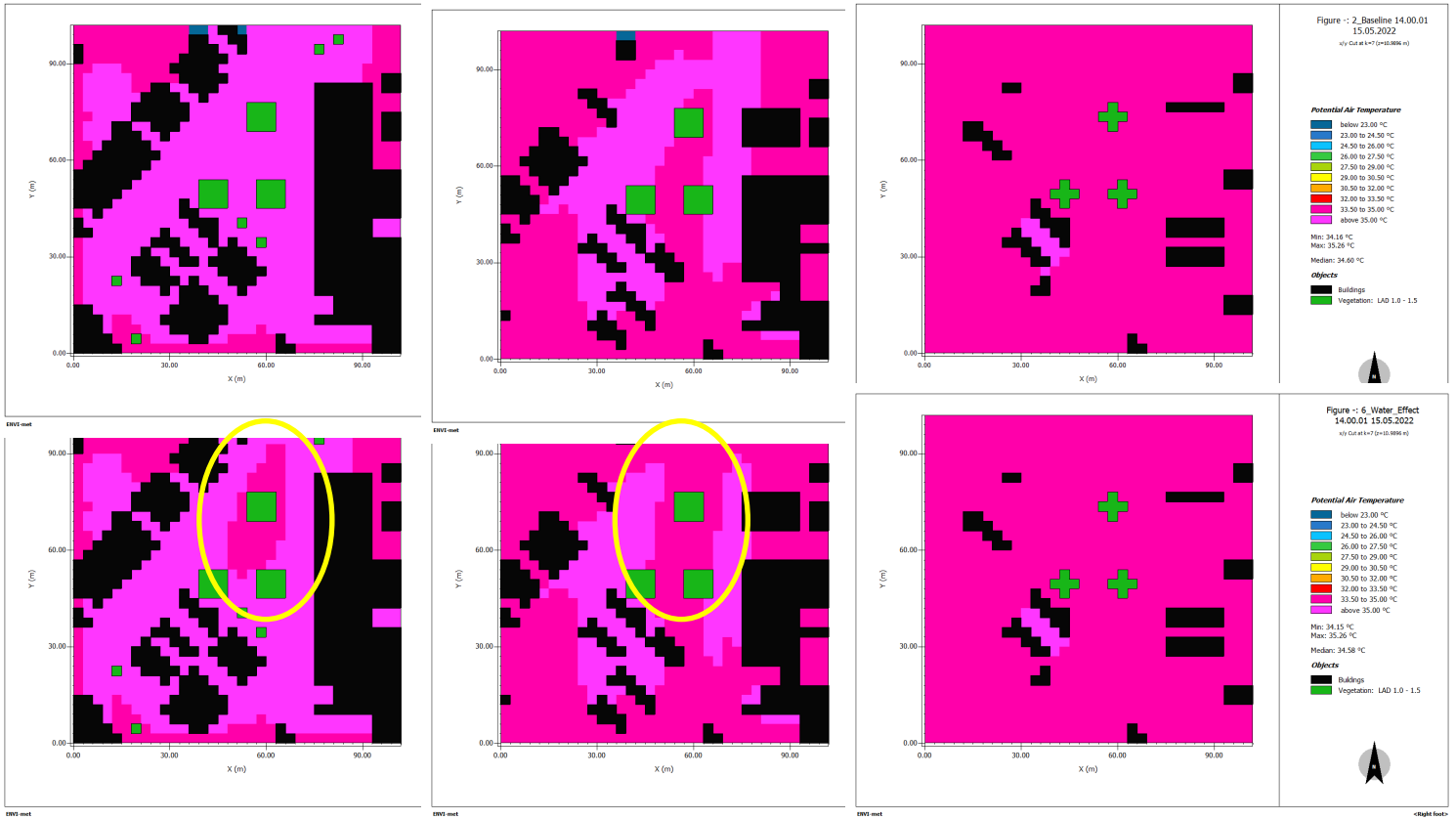




Much less heat stress / health-related risks thanks to the cooling effects of the water fountain

Blue infrastructure

Measured at 16:00, different levels – Cooling effects of water



Baseline model

Water fountain

4.5 m

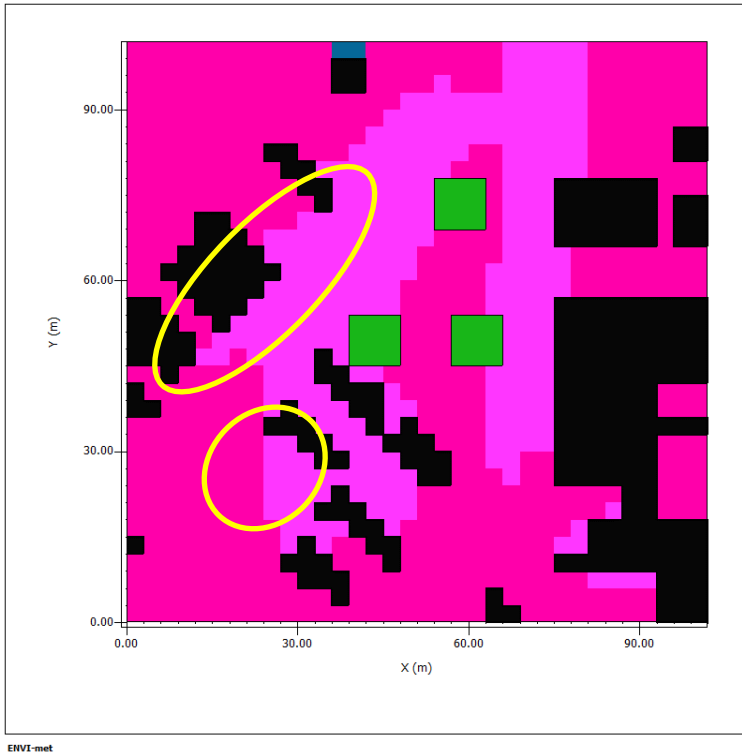
7.6 m

11.0 m

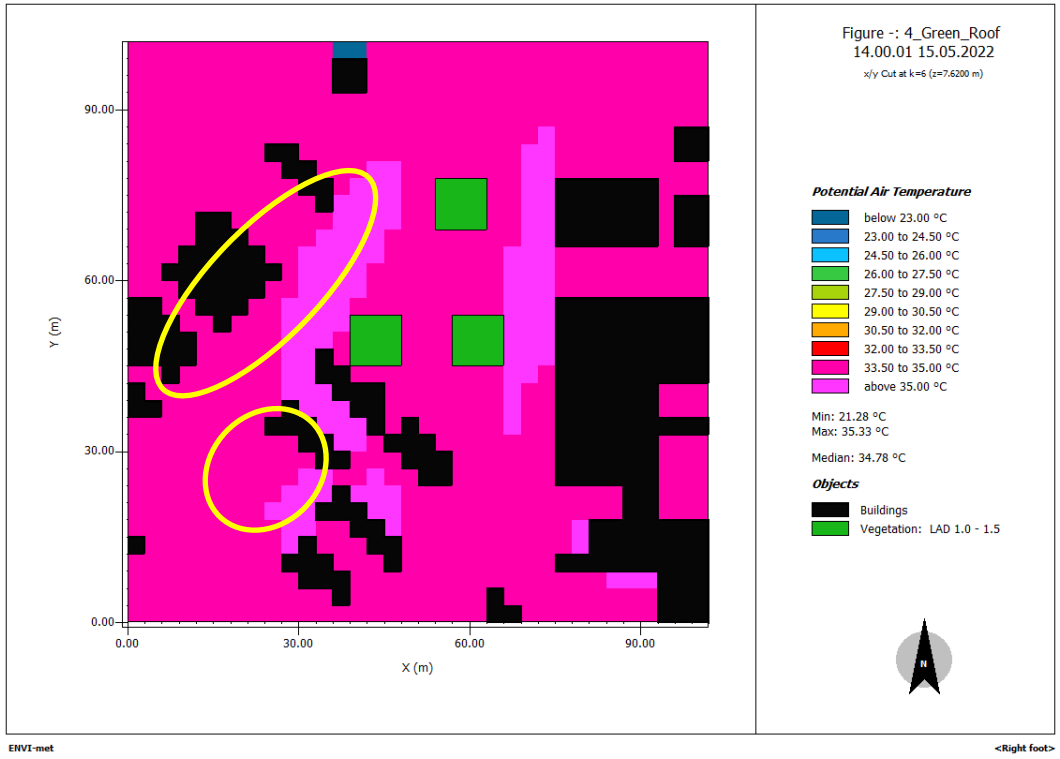
The cooling effects of the water fountain (10 m high) presents up to 7,6 m, at and surrounding the water surfaces and spread along the wind direction.

Green infrastructure

Measured at 16:00, 7.6m high - Cooling effects of greenery



Baseline model



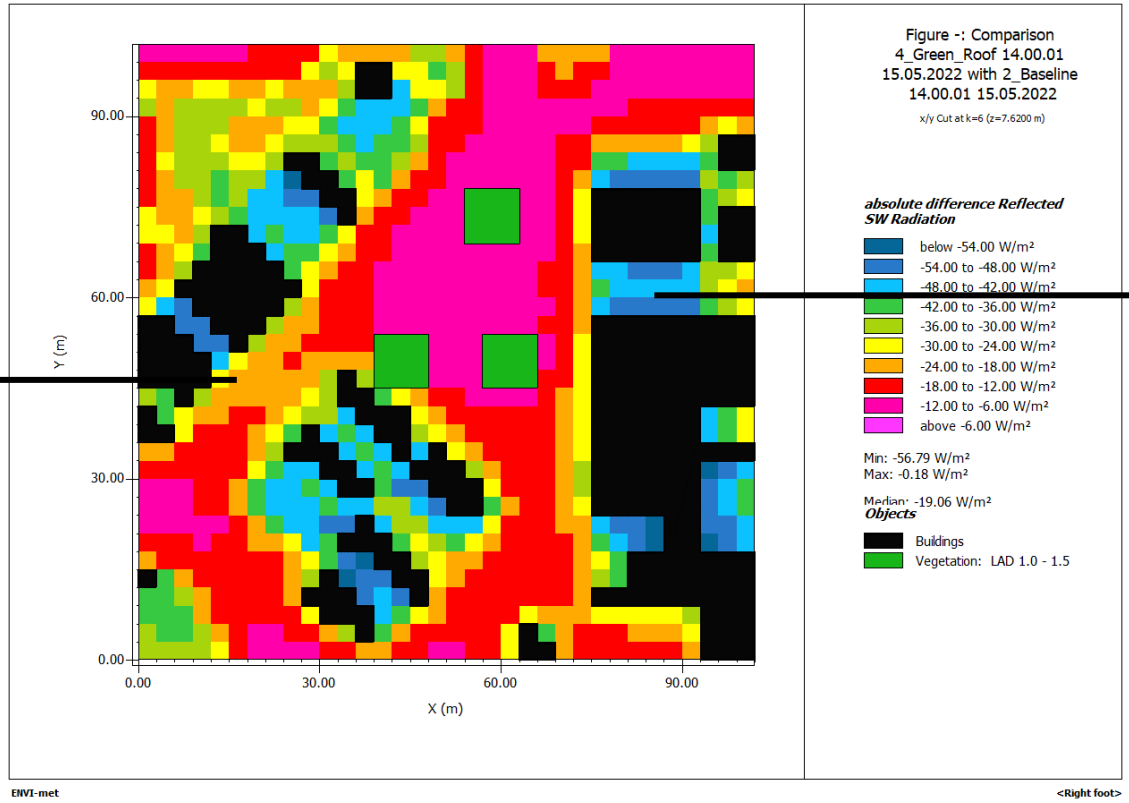
Green roof and green wall

The cooling effects of greenery are reflected through the differences in potential air temperatures.

Green infrastructure

Measured at 16:00, 7.6m high - Cooling effects of greenery

Along the greenery surfaces



In the buildings‘ self-shadows

A comparison of the reflected Southwest radiation between the baseline scenario and the Green Roof-Green Wall scenario

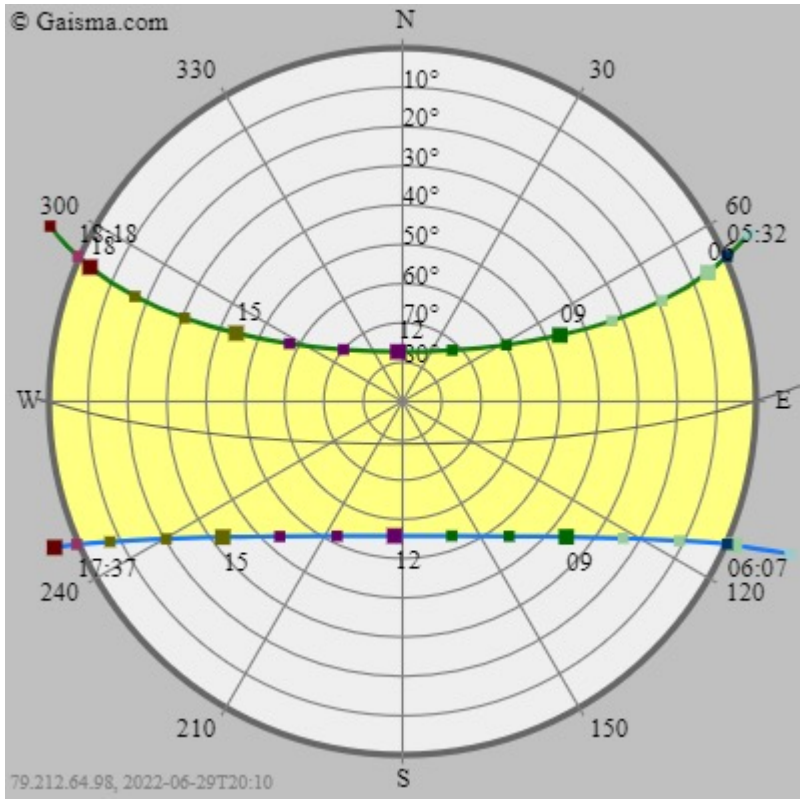
The cooling effects are explained by the reduction of the reflected radiation flux.

Conclusion

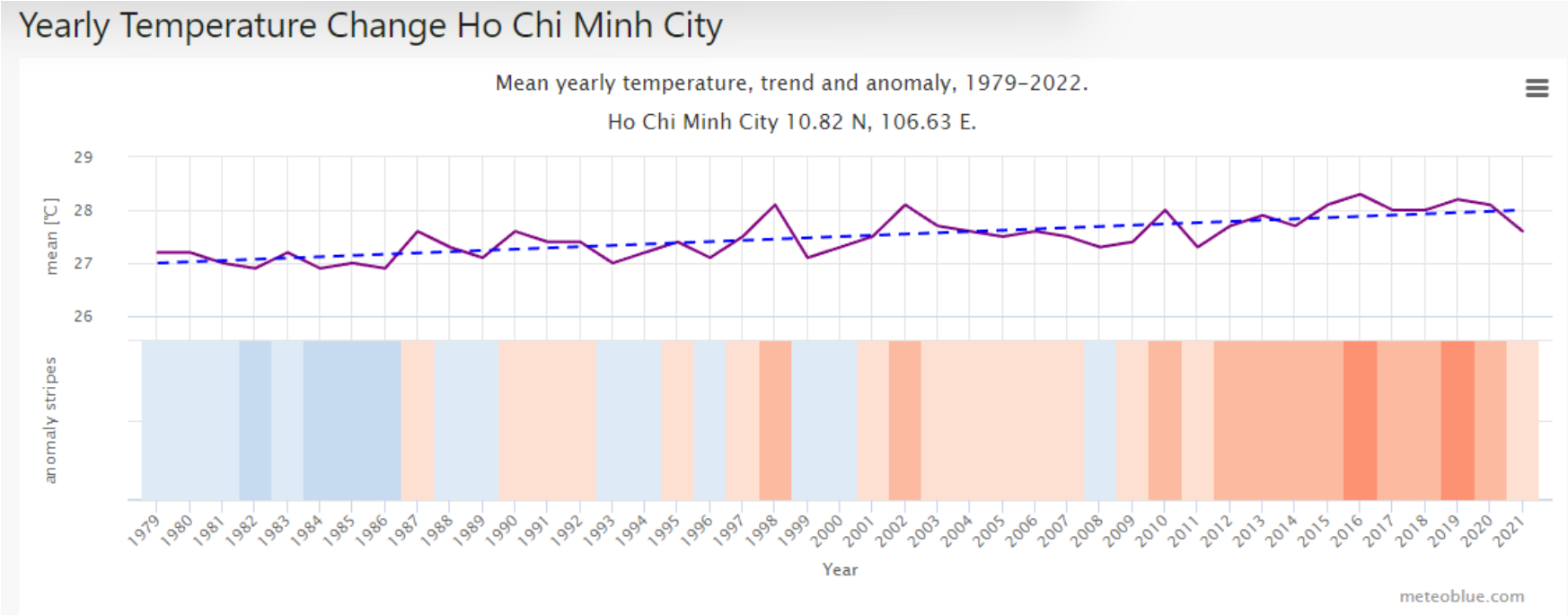
TECHNISCHE UNIVERSITÄT DARMSTADT

- The thermodynamic simulation proves that blue and green infrastructure can help to mitigate severe microclimatic conditions and therefore reduce health-related risks.
- The cooling effects of blue infrastructure:
  - are most efficient at the lower elevation level (pedestrian level)
  - is presented at and close to the water body
  - follow the prevailing wind direction
  - should be considered in urban design for outdoor thermal comfort.
- The cooling effects of green infrastructure:
  - are found along the greenery surfaces thanks to the reduction of radiant heat flux, especially from the built surfaces towards the sun direction
  - should be considered in urban design for outdoor thermal comfort and in Green Building design for indoor thermal comfort.

Sunpath diagram



Climate Change Evidence



TECHNISCHE UNIVERSITÄT DARMSTADT

www.kgbauko.de