Improvement of the Outdoor Thermal Comfort in Hot Humid Regions

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

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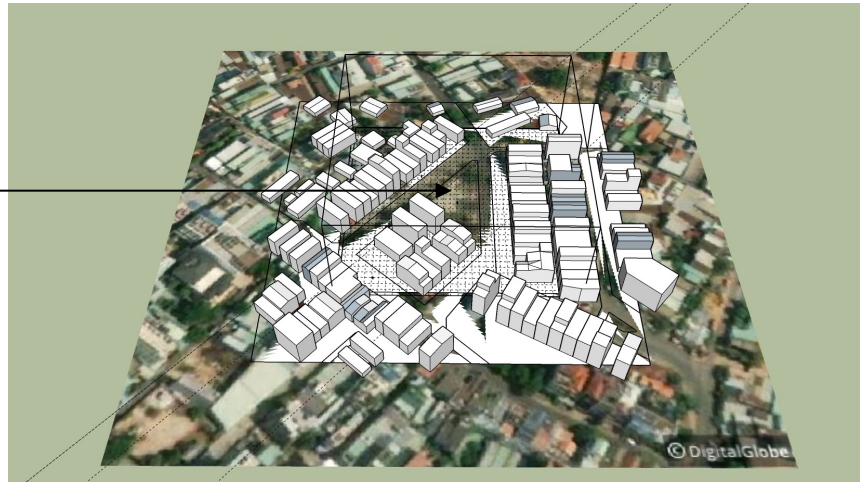
Overall information

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)

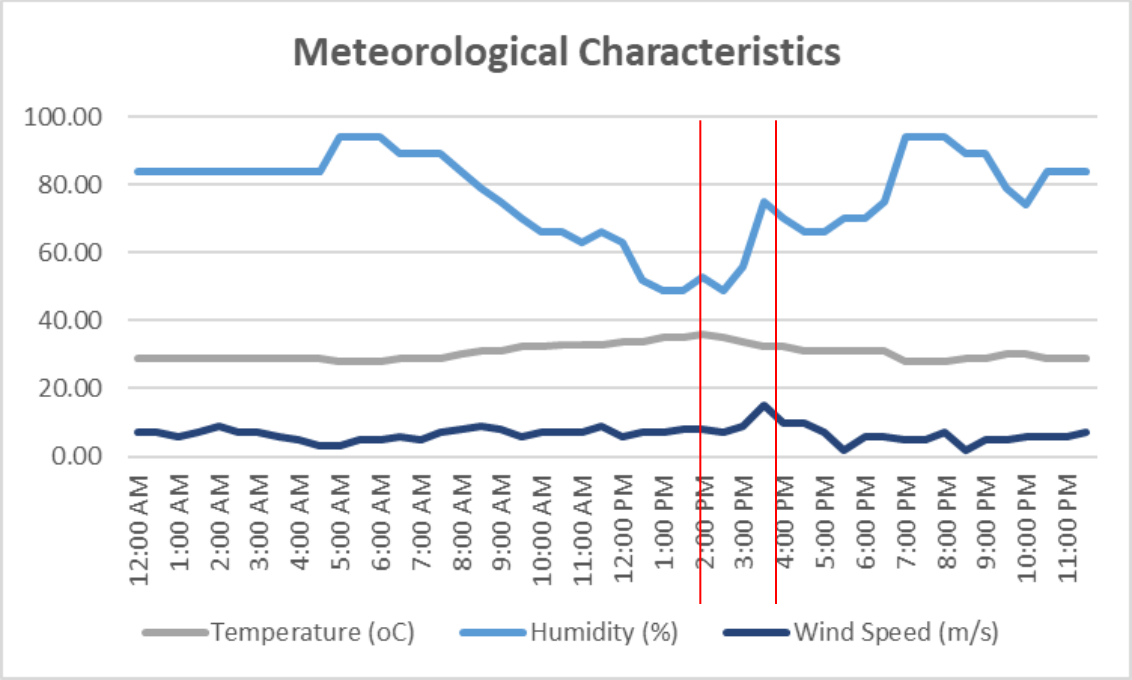
Site location on map



Overall information

Time settings

- Date and time for the thermodynamic simulation
  - On 15.05.2022: It was the hottest day in the dry season (a.k.a. the hottest day in the year)
  - At 14:00: The time with the highest air temperature and the lowest humidity
  - At 16:00: The time with the highest wind speed (Wind direction: South)



Thermal comfort

PET index

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- Physiological Equivalent Temperature (PET) index was obtained to evaluate the level of thermal comfort, as recommended by Fischereit and Schlünzen (2018) (https://link.springer.com/article/10.1007/s00484-018-1591-6)
- The values were calculated at the pedestrian level (1,5m high).

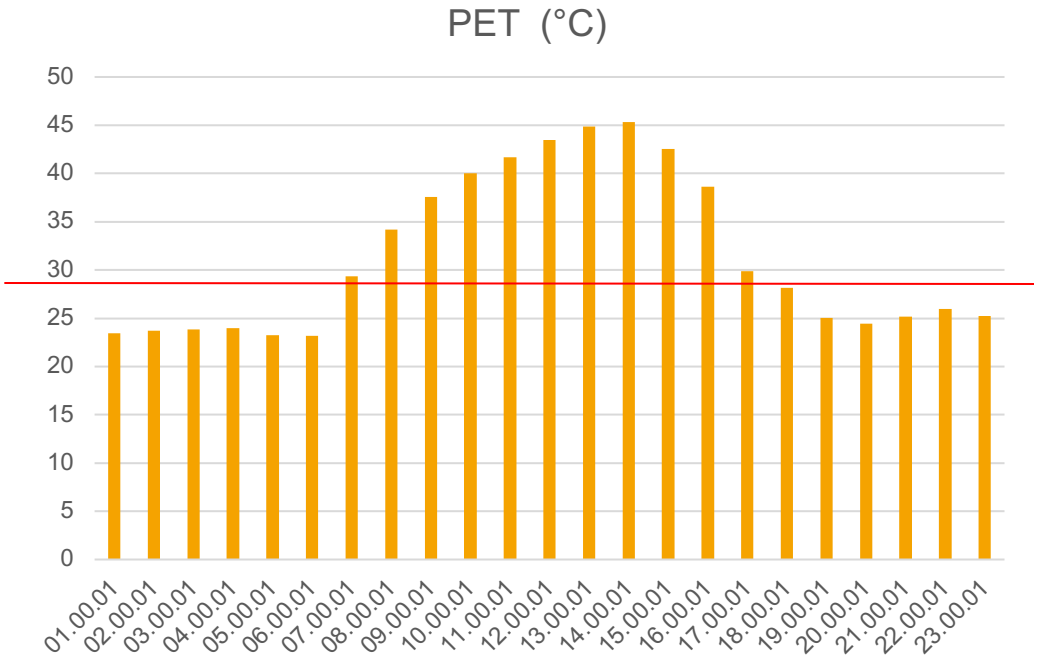
Thermal perception	Indices				
	UTCI	WBGT	SET	PMV	PET
Very cold[1] (Extreme cold stress[1,2])	< -40			-3	<4
(very strong cold stress[2])	-40 to -27				
Cold[1] (Strong cold stress[1,2])	-27 to -13			-2.5	4-8
Cool[1,3] (Moderate cold stress[1,2]/ Moderate Hazard[3])	-13 to 0		<17	-1.5	8-13
Slightly cool[1] (Slight cold stress[1,2])	0 to +9			-0.5	13-18
Comfortable[1,3] (No thermal stress[1,2]/ No Danger[3,4])	+9 to +26	<18	17-30	0	18-23
Slightly warm[1] (Slight heat stress[1])				0.5	23-29
Warm[1, 3,4] (Moderate heat stress[1,2]/ Caution[3,4])	+26 to +32	18-23	30-34	1.5	29-35
Hot[1, 3,4] (Strong heat stress[1,2]/ Extreme caution[3,4])	+32 to +38	23-28	34-37	2.5	35-41
(very strong heat stress[2])	+38 to +46				
Very hot[1, 3,4] (Extreme heat stress[1,2]/ Danger[3,4])	> +46	28-30	>37	3	>41
Sweltering[4] (extreme danger[4])		≥30			

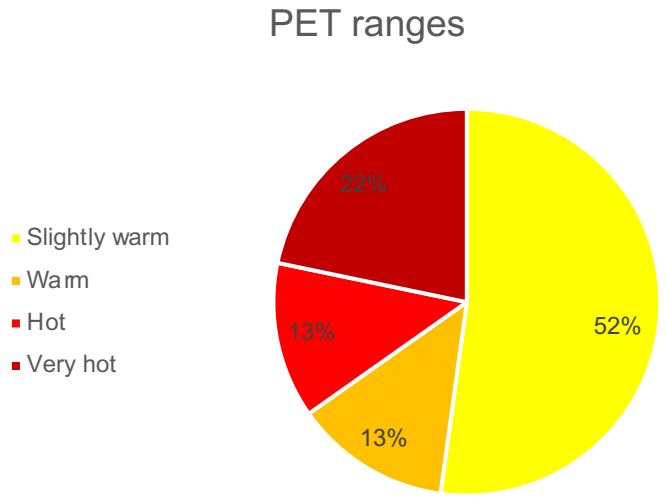
[1] PET and PMV [2]UTCI [3]SET [4] WBGT

Source:
https://www.sciencedirect.com/science/article/pii/S221209471730110X

Thermal comfort

PET values and ranges in a day – high health-related risks

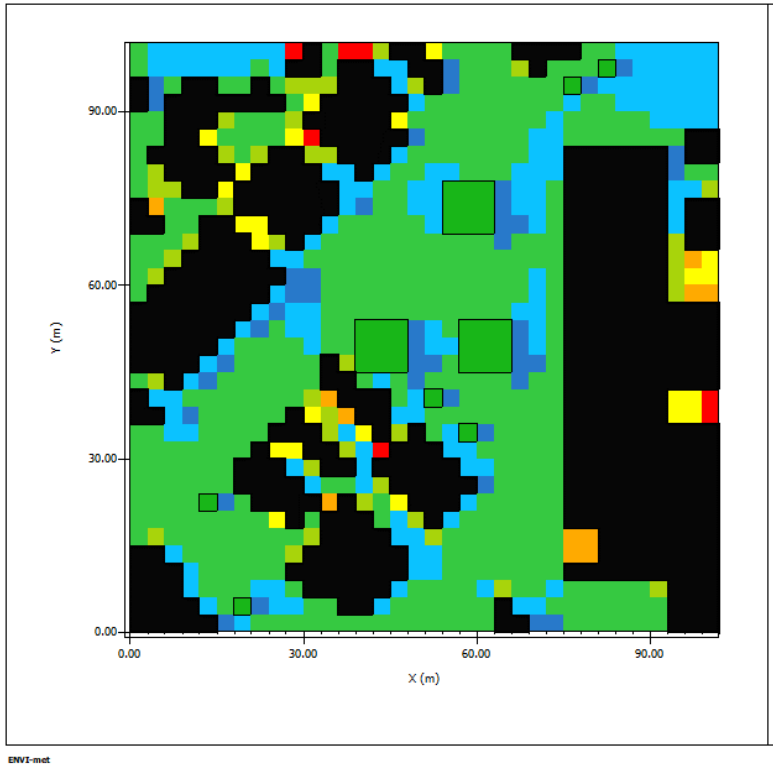


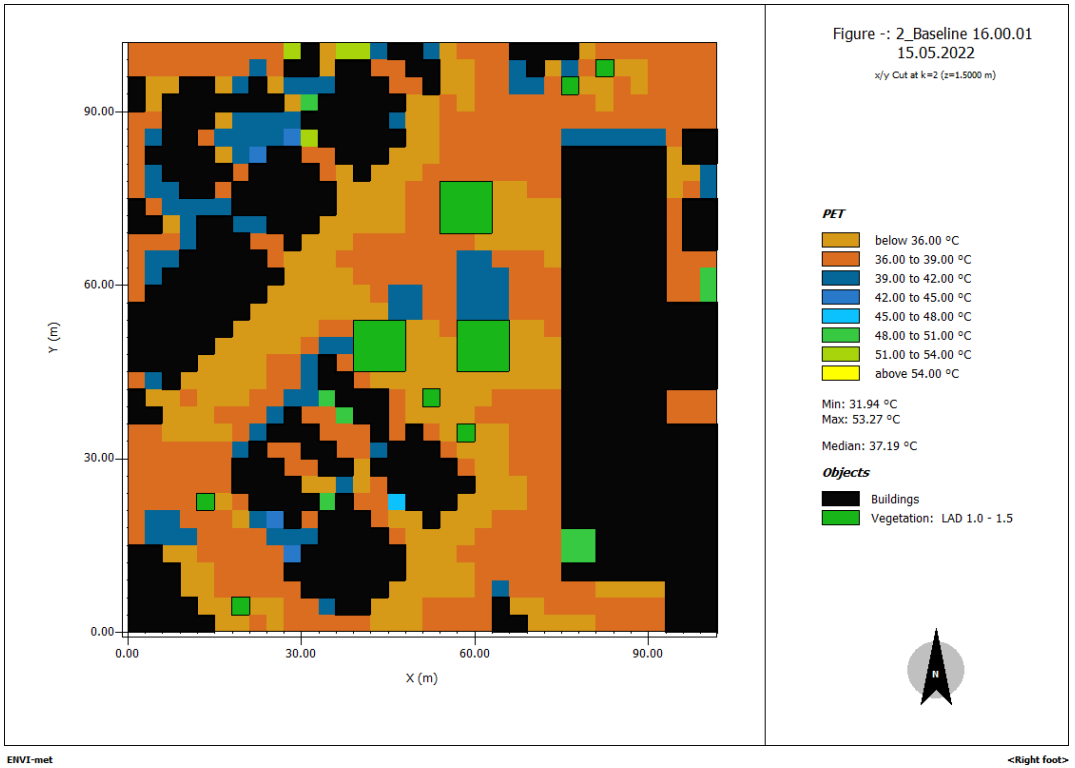


- Ranging from slight warm (slight heat stress) to very hot (extreme heat stress)
- PET values from 7:00 to 17:00 are accessed with “hot” and “very hot” thermal perception

Thermal comfort

Measured at 14:00 and 16:00 – Changes in thermal comfort levels





Baseline model at 14:00

Range: 35.79 – 59.34 °C

Mean: **45.36 °C – very hot**

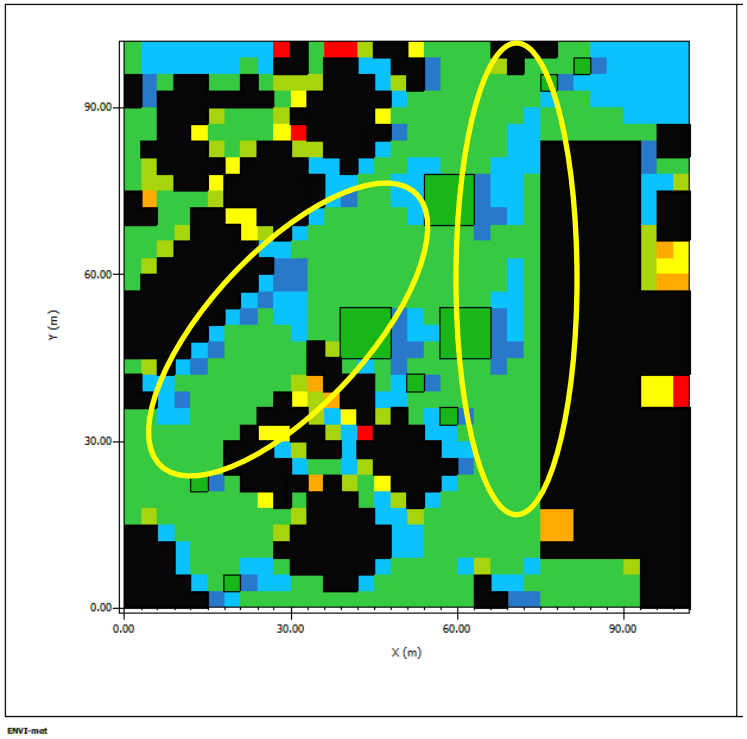
Baseline model at 16:00

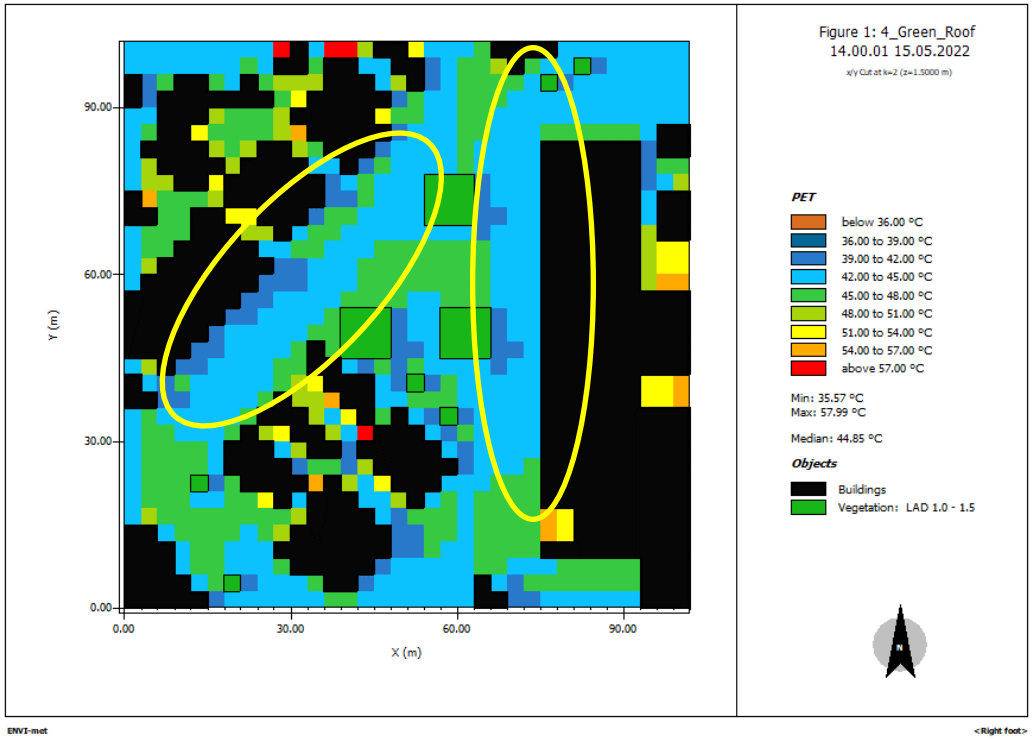
Range: 31.79 – 53.27 °C

Mean: **37.19 °C - hot**

Thermal comfort

Measured at 14:00 - Cooling effects along the green walls





Baseline model at 14:00

Range: 35.79 – 59.34 °C

Mean: 45.36 °C – very hot

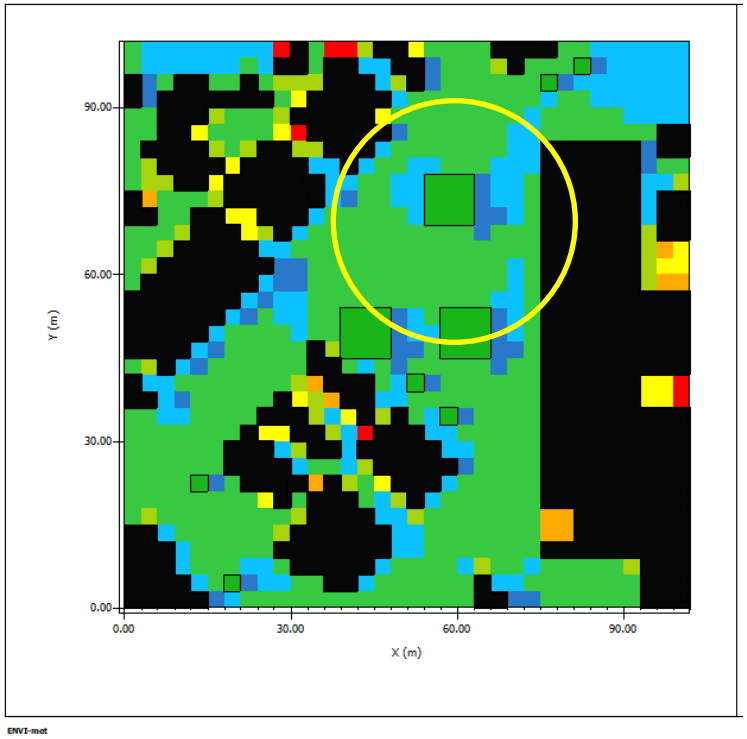
Green roof and green wall

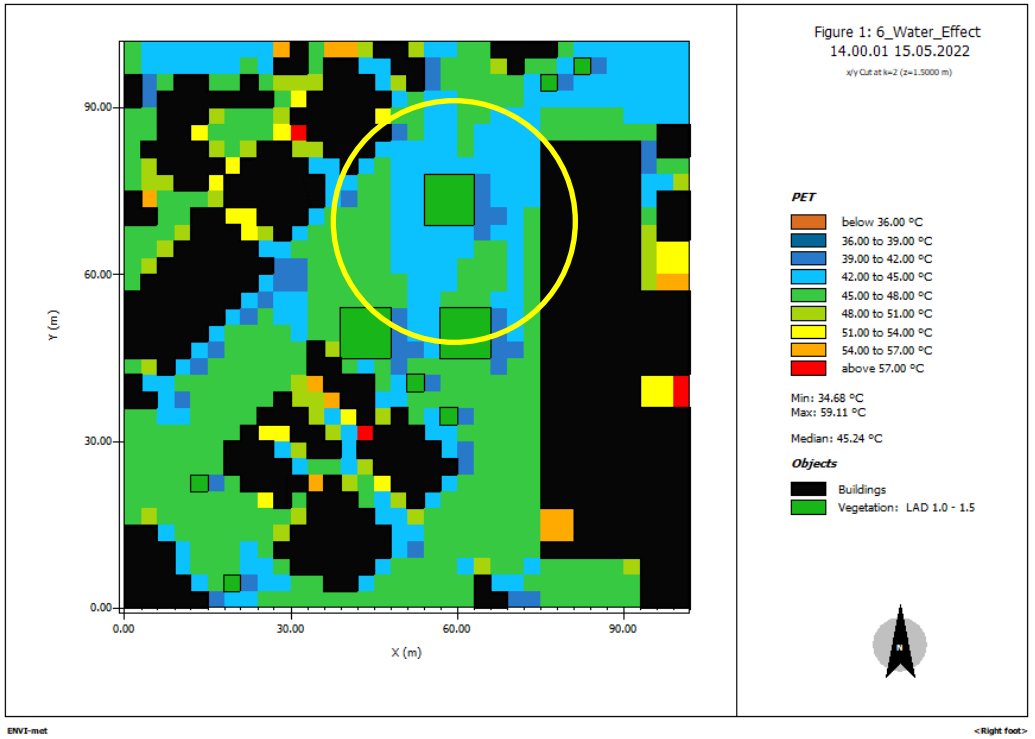
Range: 35.57 – 57.99 °C

Mean: 44.85 °C – very hot

Thermal comfort

Measured at 14:00 – Cooling effects at the water surface and expanding towards the prevailing wind direction





Baseline model at 14:00

Range: 35.79 – 59.34 °C

Mean: 45.36 °C – very hot

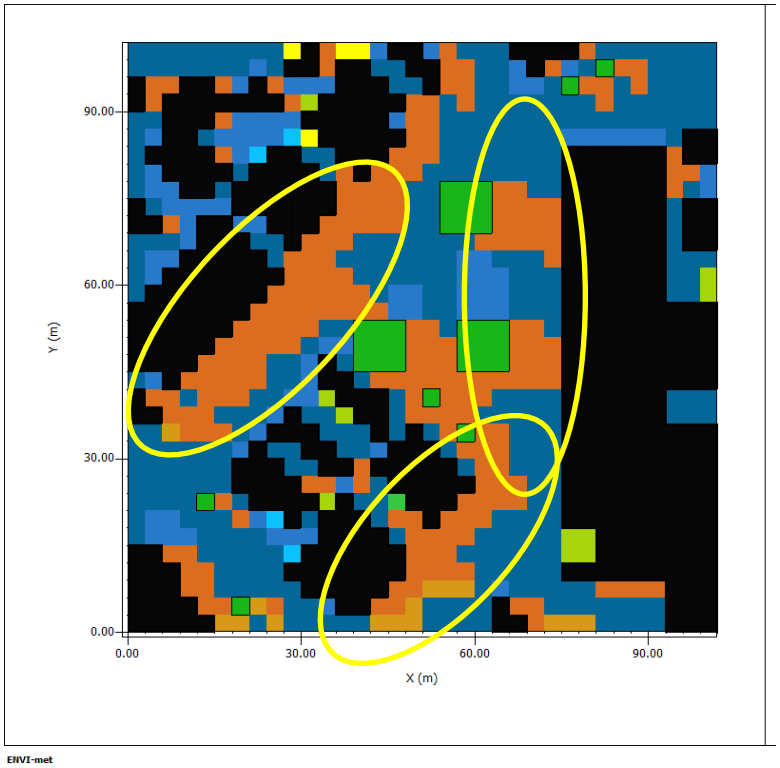
Water fountain

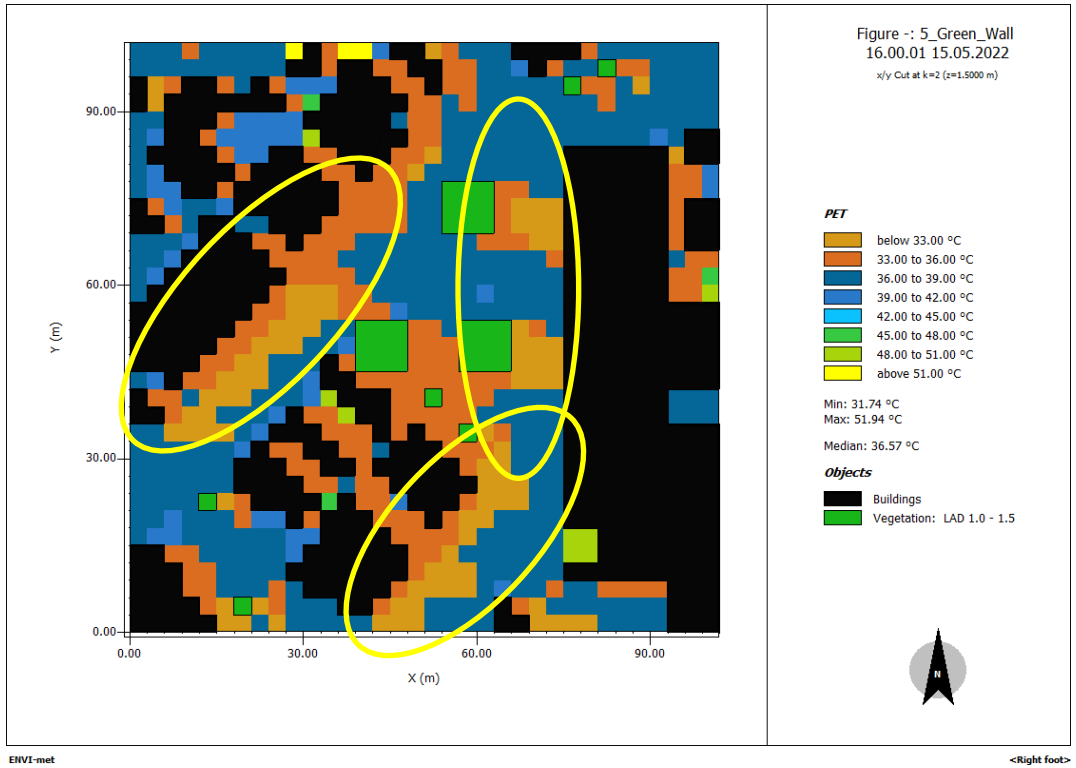
Range: 34.68 – 59.11 °C

Mean: 45.24 °C – very hot

Thermal comfort

Measured at 16:00 - Cooling effects along the green walls and in the shadows





Baseline model at 16:00

Range: 31.79 – 53.27 °C

Mean: 37.19 °C - hot

Green roof and green wall

Range: 31.71 – 51.94 °C

Mean: 36.57 °C – hot

Thermal comfort

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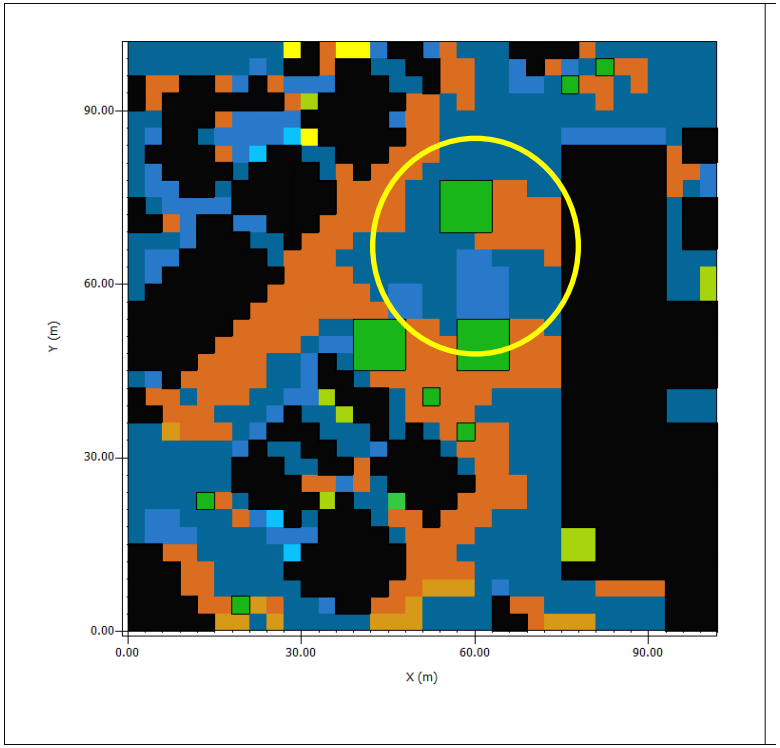
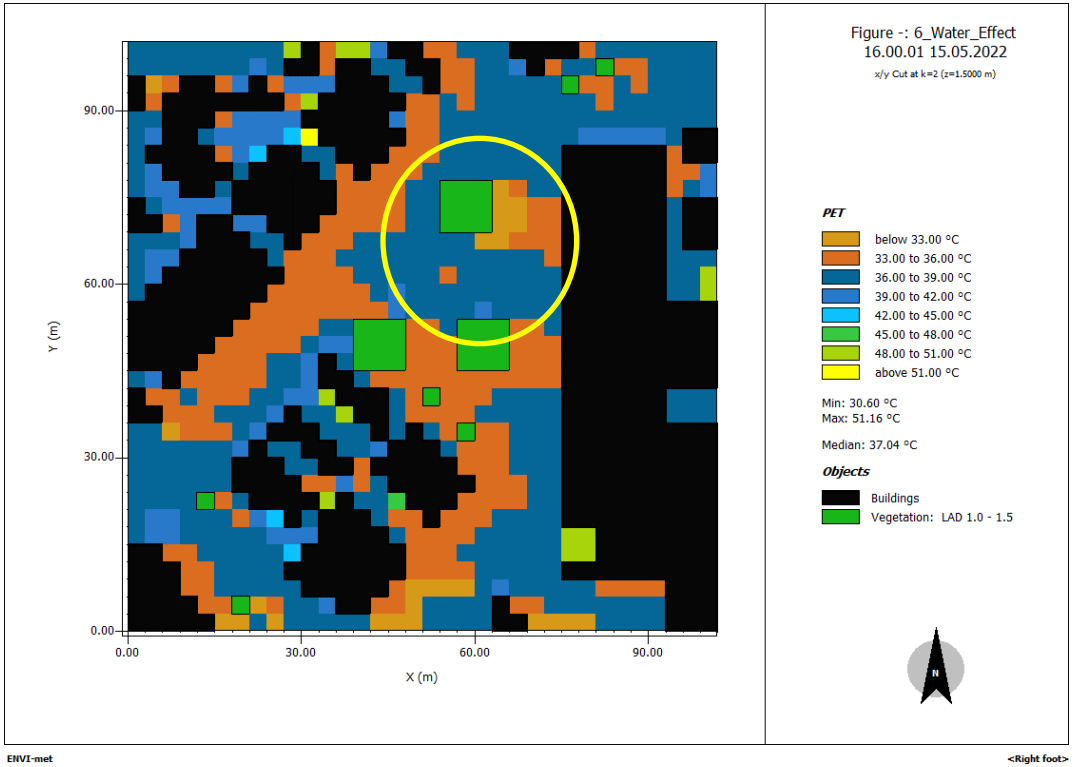
Measured at 16:00 - Cooling effects at and surrounding the water surface





Baseline model at 16:00

Range: 31.79 – 53.27 °C

Mean: 37.19 °C - hot

Water fountain (wind direction: South)

Range: 30.60 – 51.16 °C

Mean: 37.04 °C – hot

Conclusion

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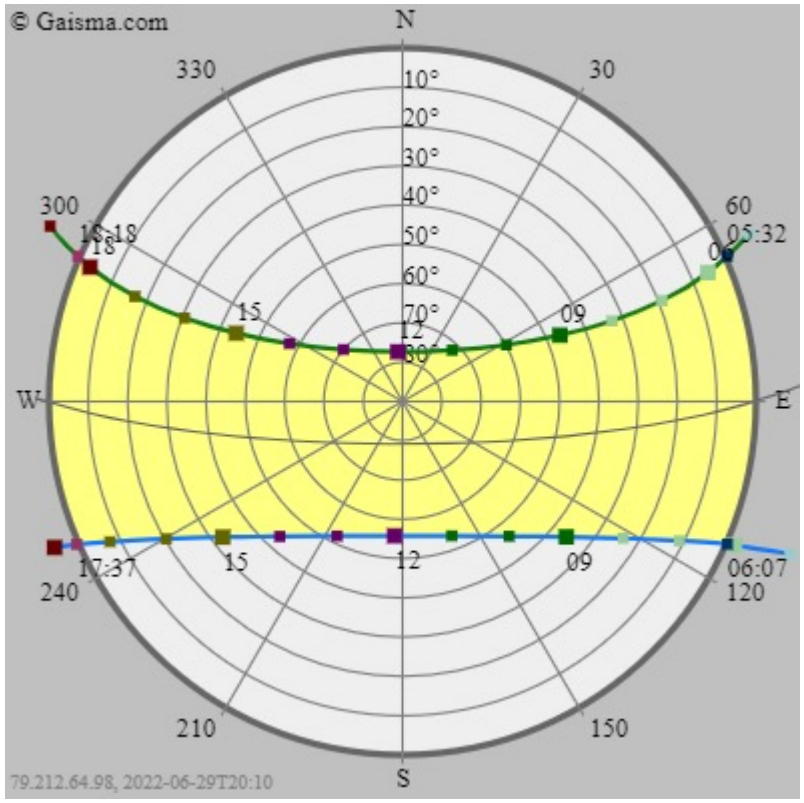
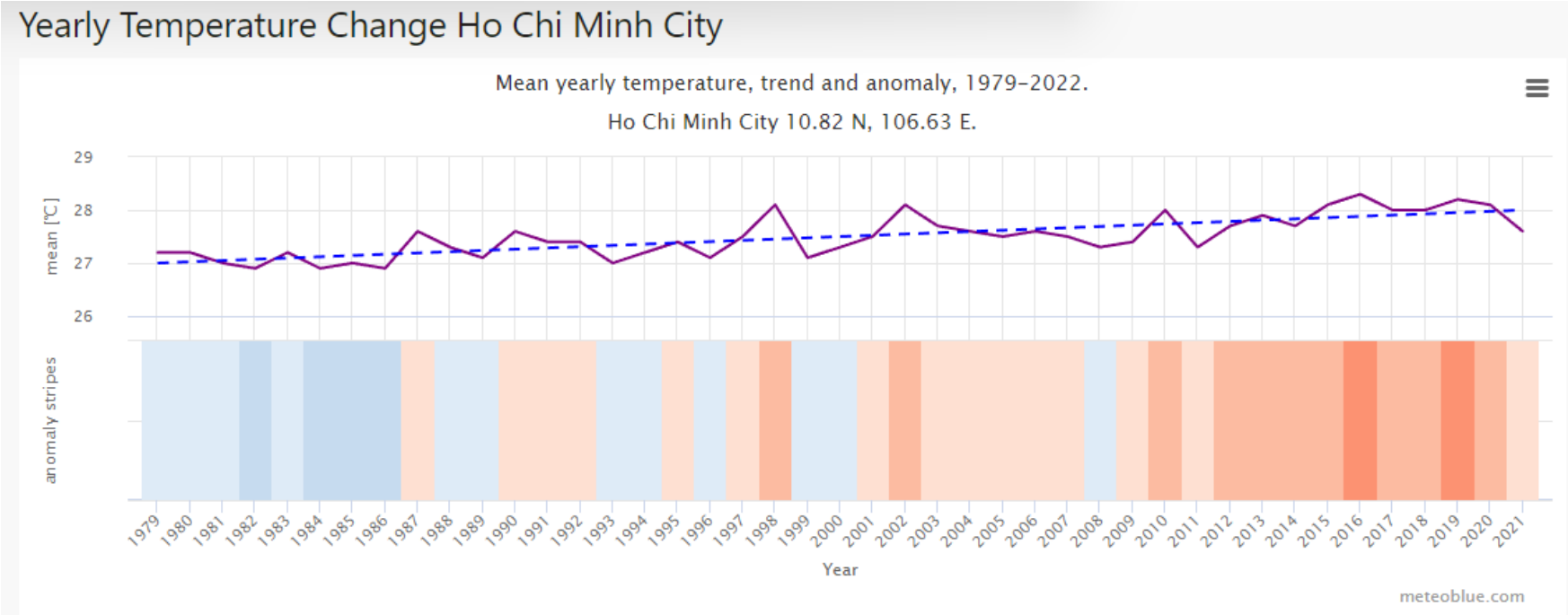
- Evaluating thermal comfort proves the existing heat stress and high potential health-related risks.
- Thermal discomfort was found during the time that people were most active (7:00 to 17:00).
- The thermodynamic simulation proves that thermal discomfort can be mitigated using greenery and water. Cooling effects were found:
    - In the tree shadow
    - Along the green wall surfaces
    - On and surrounding the water surfaces
- Cooling effects by water surfaces can reach a larger area following the prevailing wind direction. Urban design should consider wind direction to take advantage of this factor.
- Greenery can bring further health-related benefits such as psychological impacts due to its visual and audio effects (white sound).

Sunpath diagram



Climate Change Evidence



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