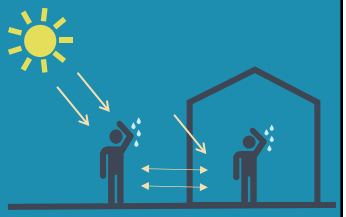
KU LEUVEN GENT

Outdoor Microclimate Variations and Indoor Thermal Stress: Summer Field Measurements in an Elderly Care Facility



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PhD Strategic Basic Research Fellowship

1

Thermal Interaction between indoor & outdoor

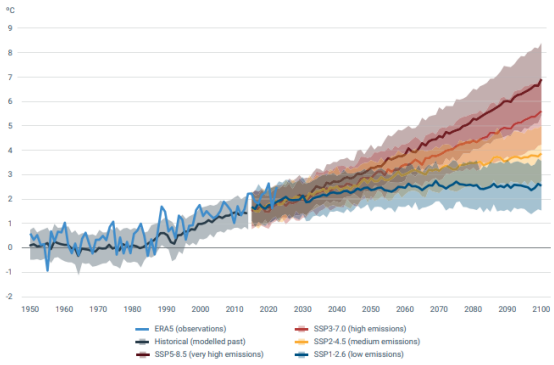
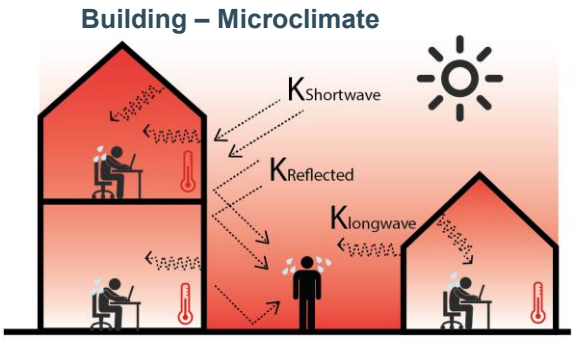


Fig.1 Observed and projected temperature increase over European land area [1]

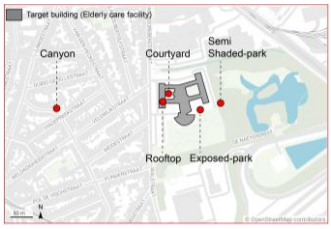


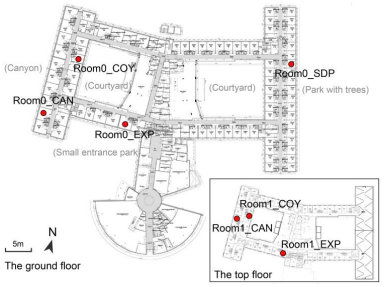
Building (Indoors) – Microclimate (Outdoors) thermal interaction

[1] European Environment Agency Report (2024). European Climate Risk Assessment Executive summary

2

WORKFLOW





Outdoor thermal condition (Physiological Equivalent Temperature, PET)

Air temperature,
Black globe temperature,
Relative humidity,
Wind speed,
Wind direction,
Global solar radiation

Indoor thermal condition (Standard Effective Temperature, SET)

Air temperature,
Relative humidity

Case study selection
Morphological parameters
Sky view factors;
Land cover ratios (green, impervious);
Building density, average height

Rooms selection
Ground floor & top floor
Orientation; Views; Floor level

Assessment metrics selection
Indoor & Outdoor
SET (indoor); PET (outdoor)

3

WORKFLOW

Equipment deployments
Timestep (accuracy vs power cost); Interruption (power/internet outage);
Permission; Safety; Distance from the sensor consoles;

4

Assessment (Local climatic condition)

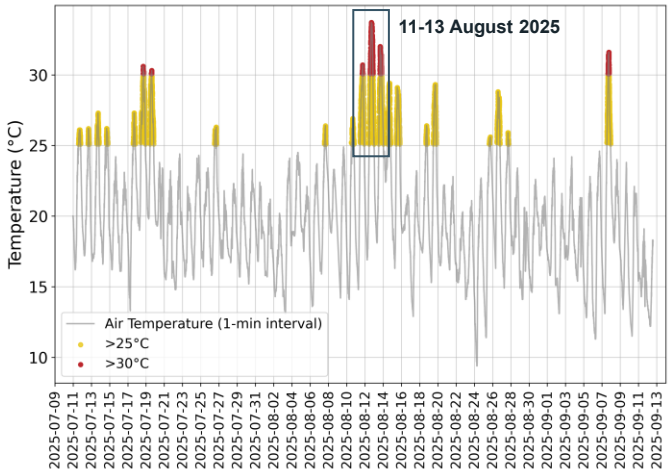


Fig.2 Air temperature at rooftop of the target building between 11 July and 12 September 2025

Assessment (outdoor thermal conditions)

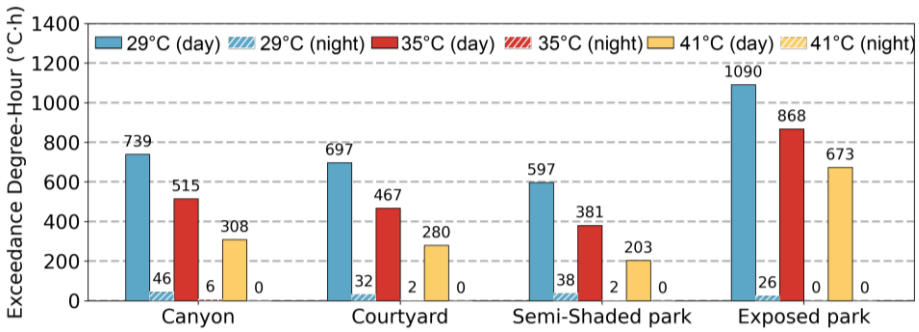


Fig.3 Exceedance degree-hour of 4 microclimate spots considering thresholds of 29°C (moderate heat stress), 35°C (strong heat stress), 41°C (extreme heat stress)

Assessment (key factor for outdoor thermal conditions)

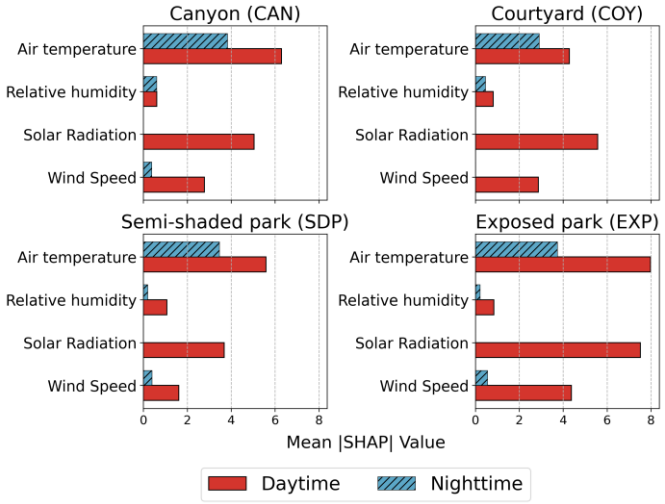
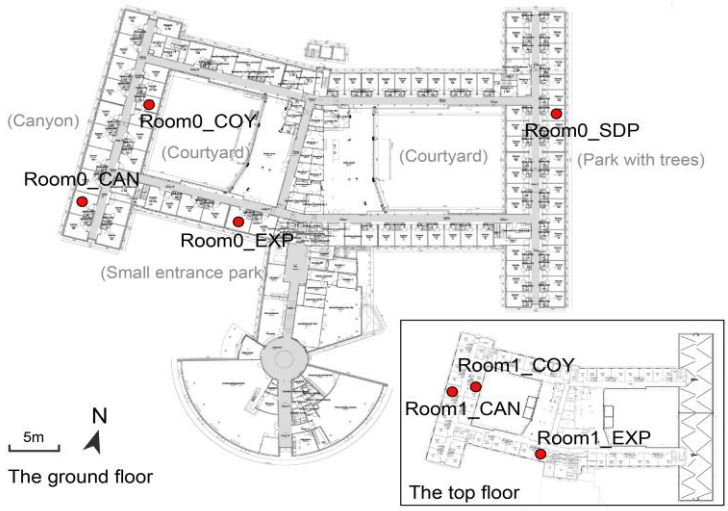


Fig. 4 Mean SHAP value of considered variables across spots during daytime and nighttime

Assessment (indoor thermal condition)



Assessment (indoor thermal condition)

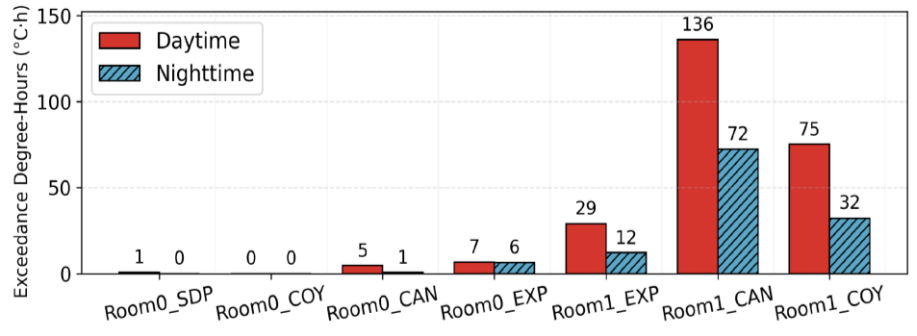


Fig.5 Exceedance Degree-hour (bottom graph) of 7 rooms from 8-16 Aug. 2025 by considering threshold of 26 °C (slight heat stress)

Assessment (indoor thermal condition differences)

Table 3. SET differences between rooms with different views and nearly same orientation.

Time	Room	Orientation	Natural Ventilation Hours (%)	Max ΔSET (°C)	P-value (Significance)
Day	0_SDP 0_COY	East-north East	34.6 35.6	1.42	0.0064 (Yes)
Night	0_SDP 0_COY	East-north East	38.5 75.0	1.30	0 (Yes)

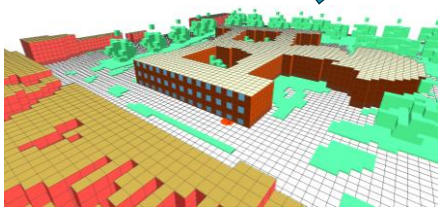
Conclusion

- **EXP** (with 83.6% SVF, 89% (11%, trees) green cover ratio, 11% impervious cover ratio)
  SDP (with 22.5% SVF, 87% (71%, trees) green cover ratio, 13% impervious cover ratio)
  COY (with 58.5% SVF, 14% (12%, trees) green cover ratio, 86% impervious cover ratio)
  CAN (with 53.1% SVF, 2% (2%, trees) green cover ratio, 98% impervious cover ratio)

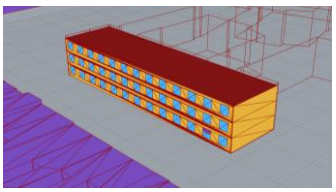
- **Air temperature and solar radiation** are the two key contributors for outdoor thermal conditions based on PET, followed by **Wind speed.**

- **Top-floor rooms face higher overheating risk than the ground-floor rooms. In addition, surrounding microclimate may also has effect on indoor thermal condition.**

On-going work for 2-ways coupled simulation



Outdoor simulation (with ENVI-Met)



Indoor simulation (with EnergyPlus)