UTS x Future Village x OCSE

Plantabox for Targeting the Urban Heat Island Challenge: Phase 2

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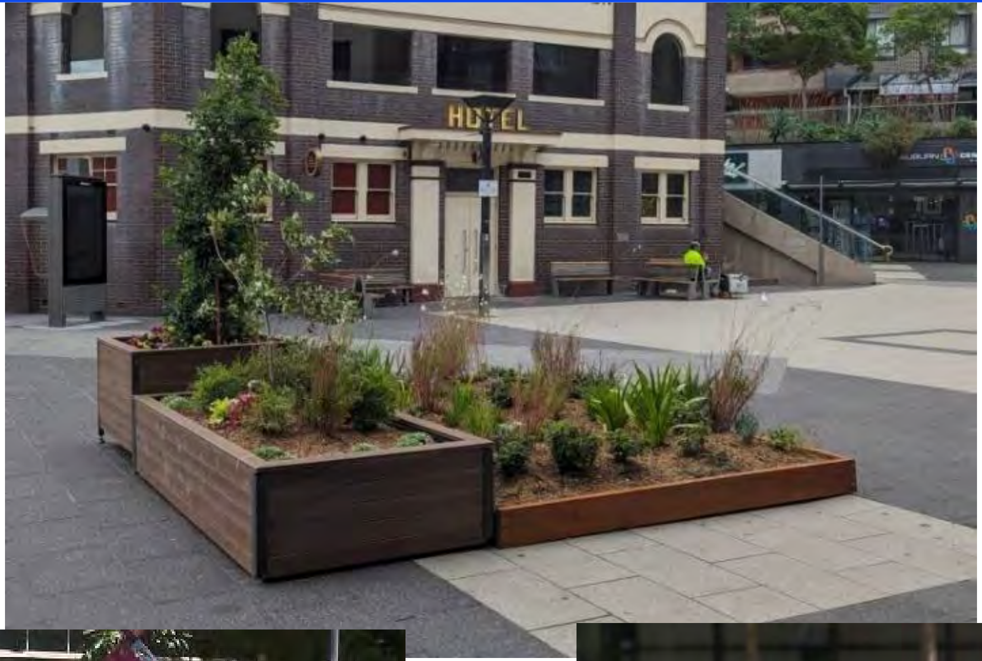
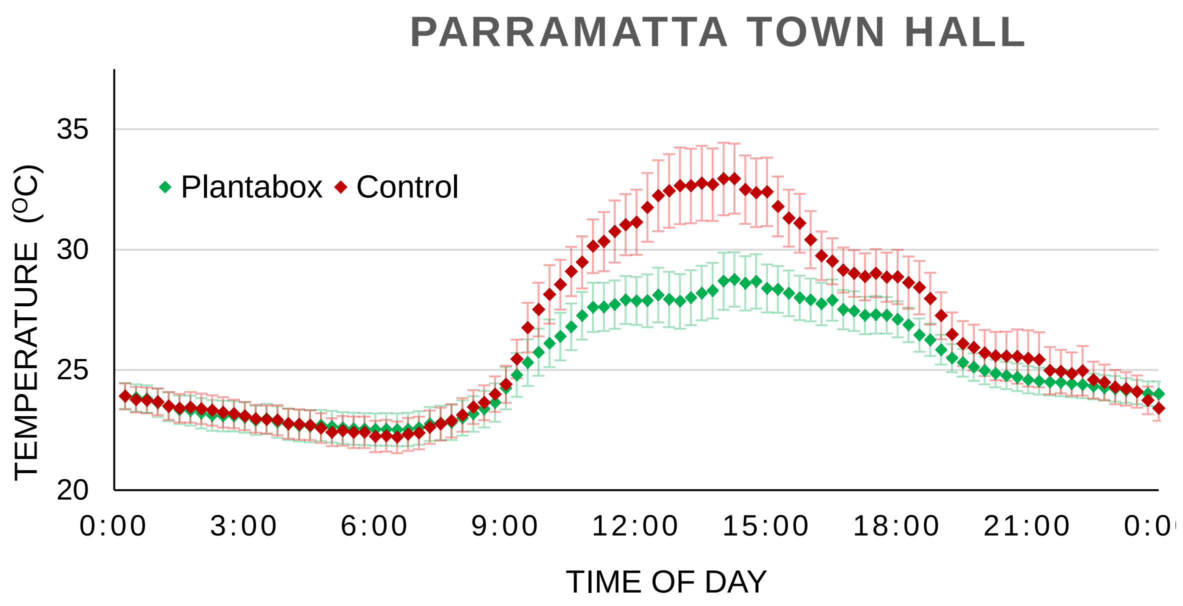
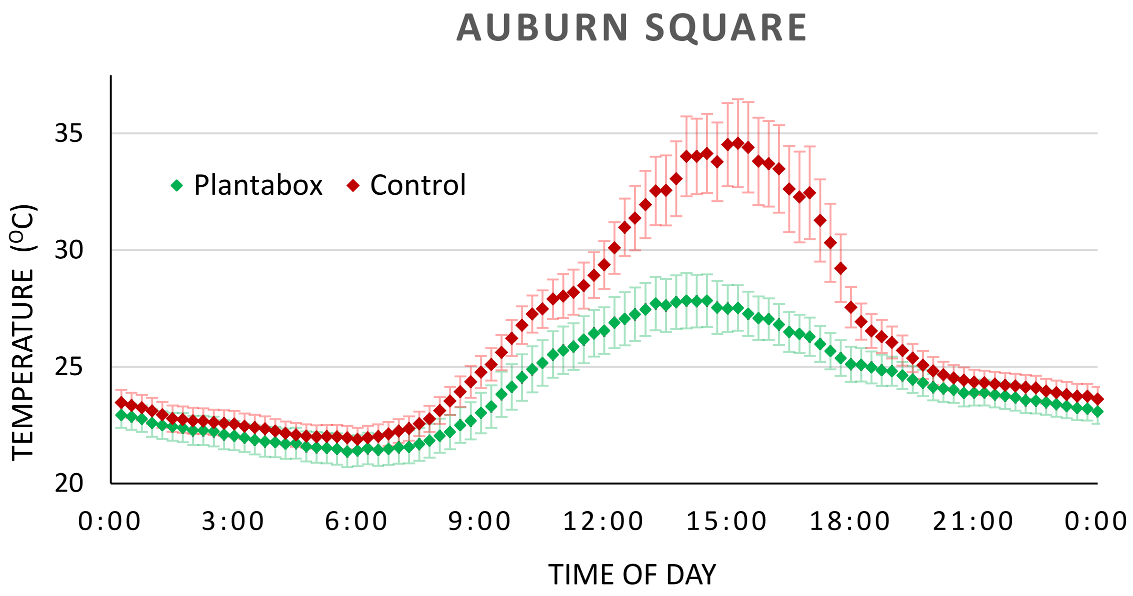
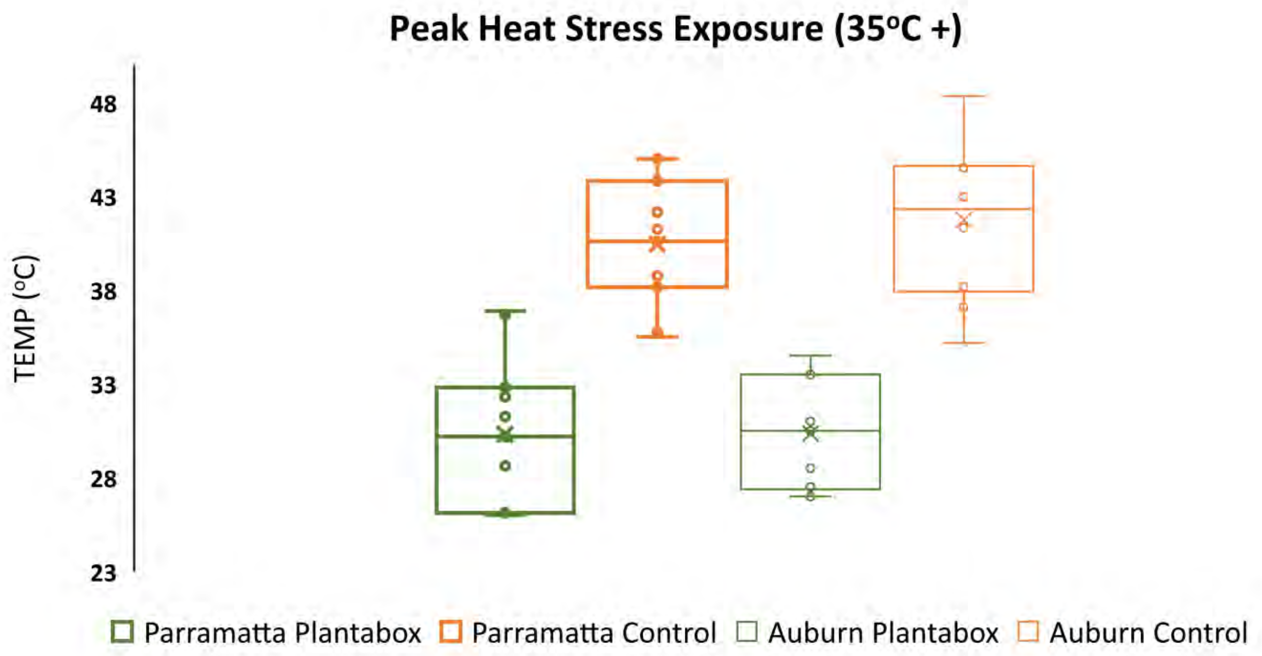
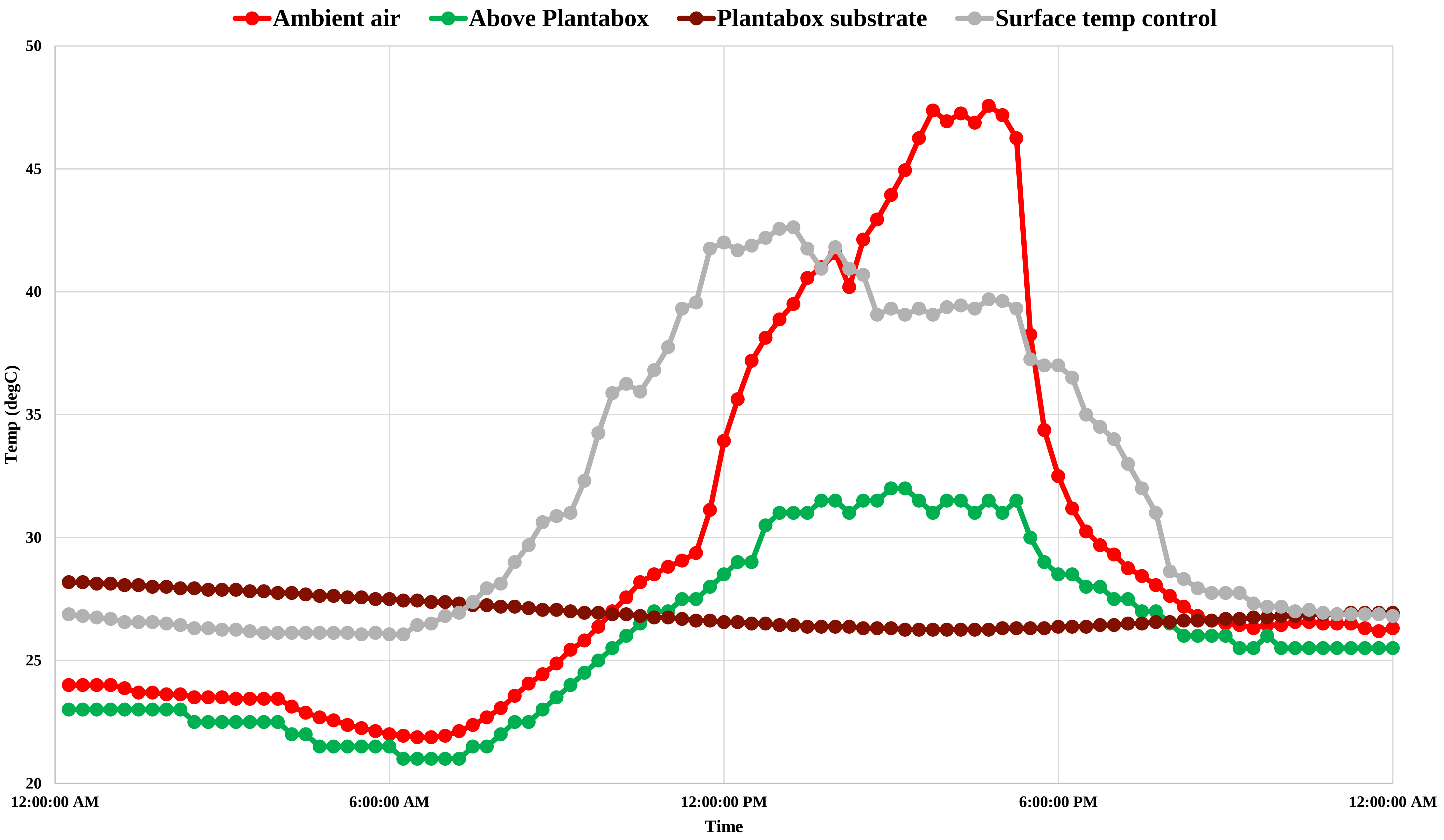
Phase 1:



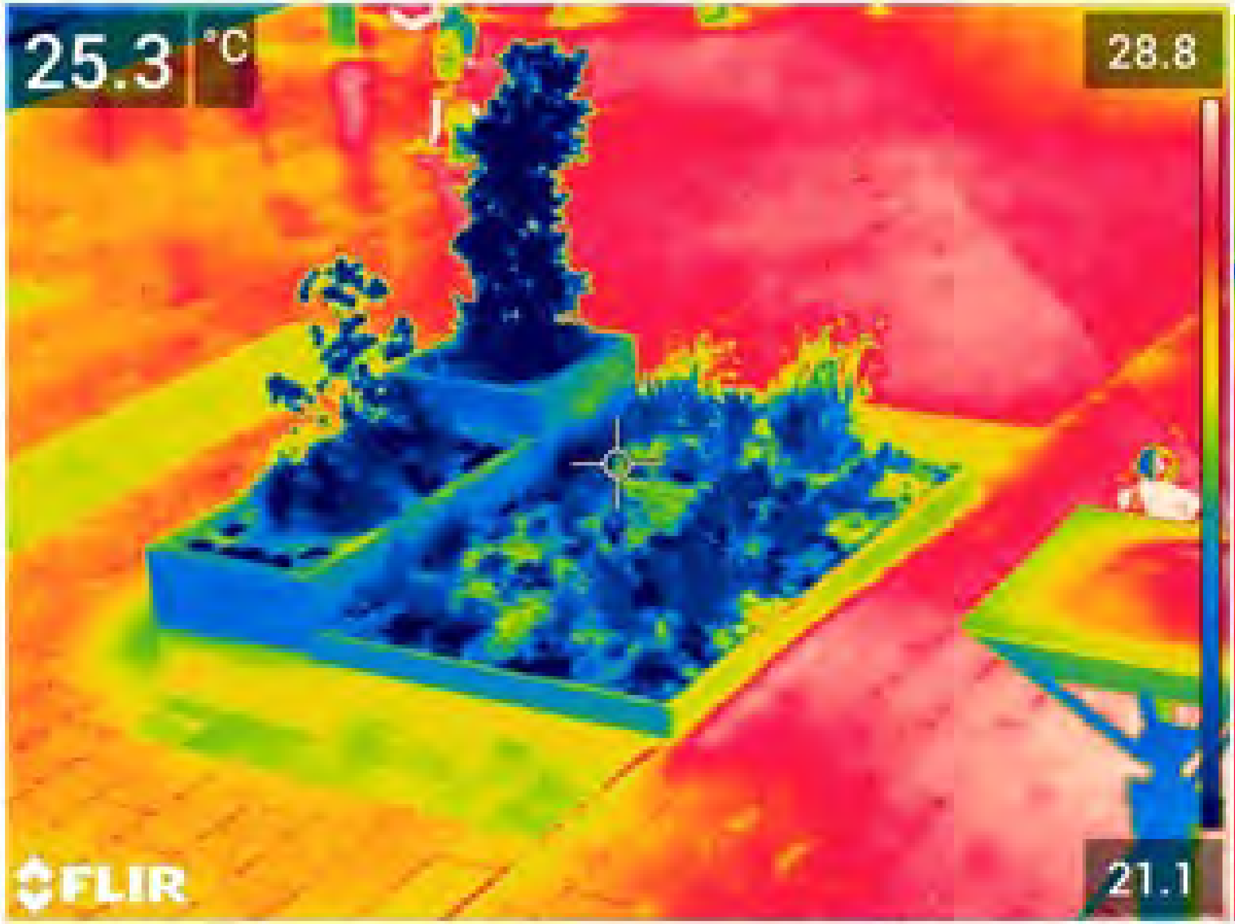

PARRAMATTA TOWN HALL
Plantabox
Control
TEMPERATURE (ºC)
35
30
25
20
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
TIME OF DAY

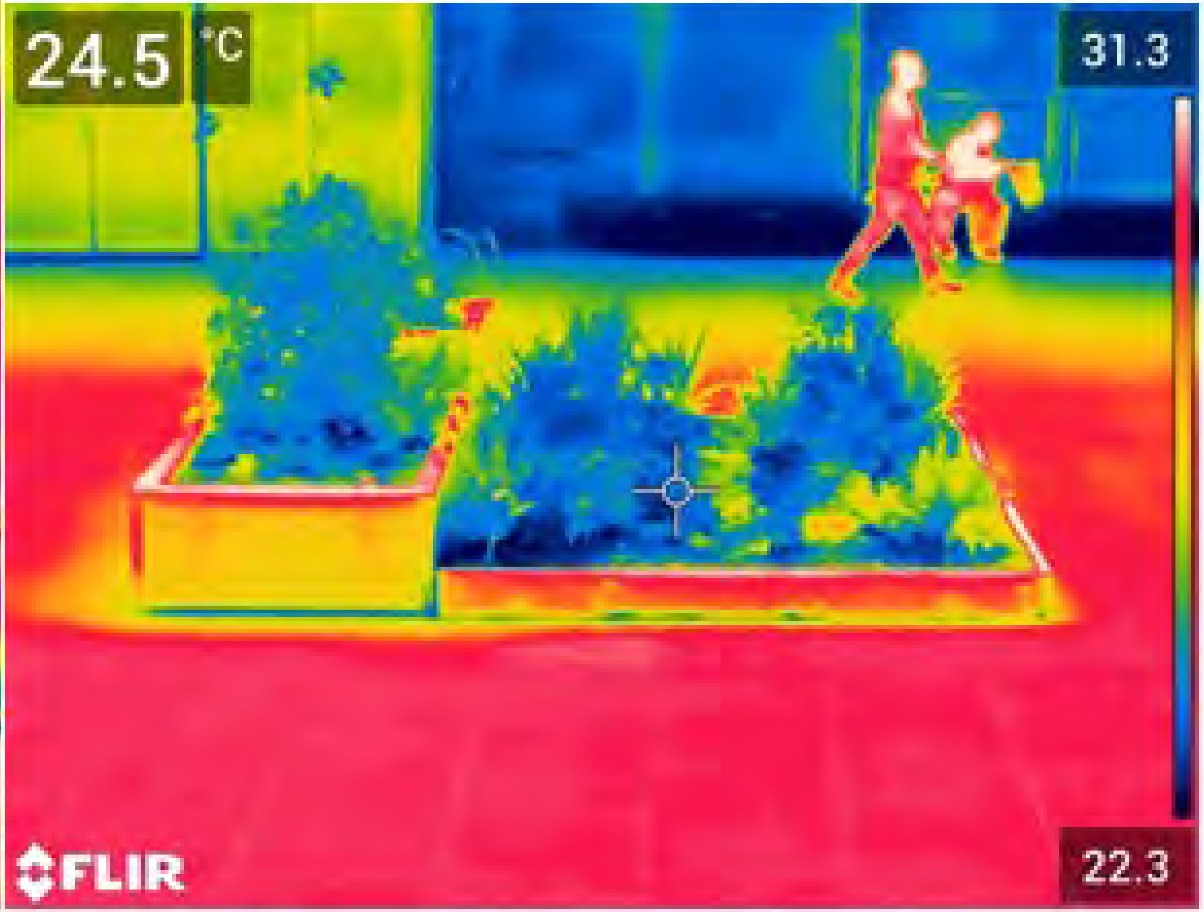

AUBURN SQUARE
Plantabox
Control
TEMPERATURE (ºC)
35
30
25
20
0:00
3:00
6:00
9:00
12:00
15:00
18:00
21:00
0:00
TIME OF DAY


Peak Heat Stress Exposure (35ºC +)
TEMP (ºC)
48
43
38
33
28
23
Parramatta Plantabox
Parramatta Control
Auburn Plantabox
Auburn Control

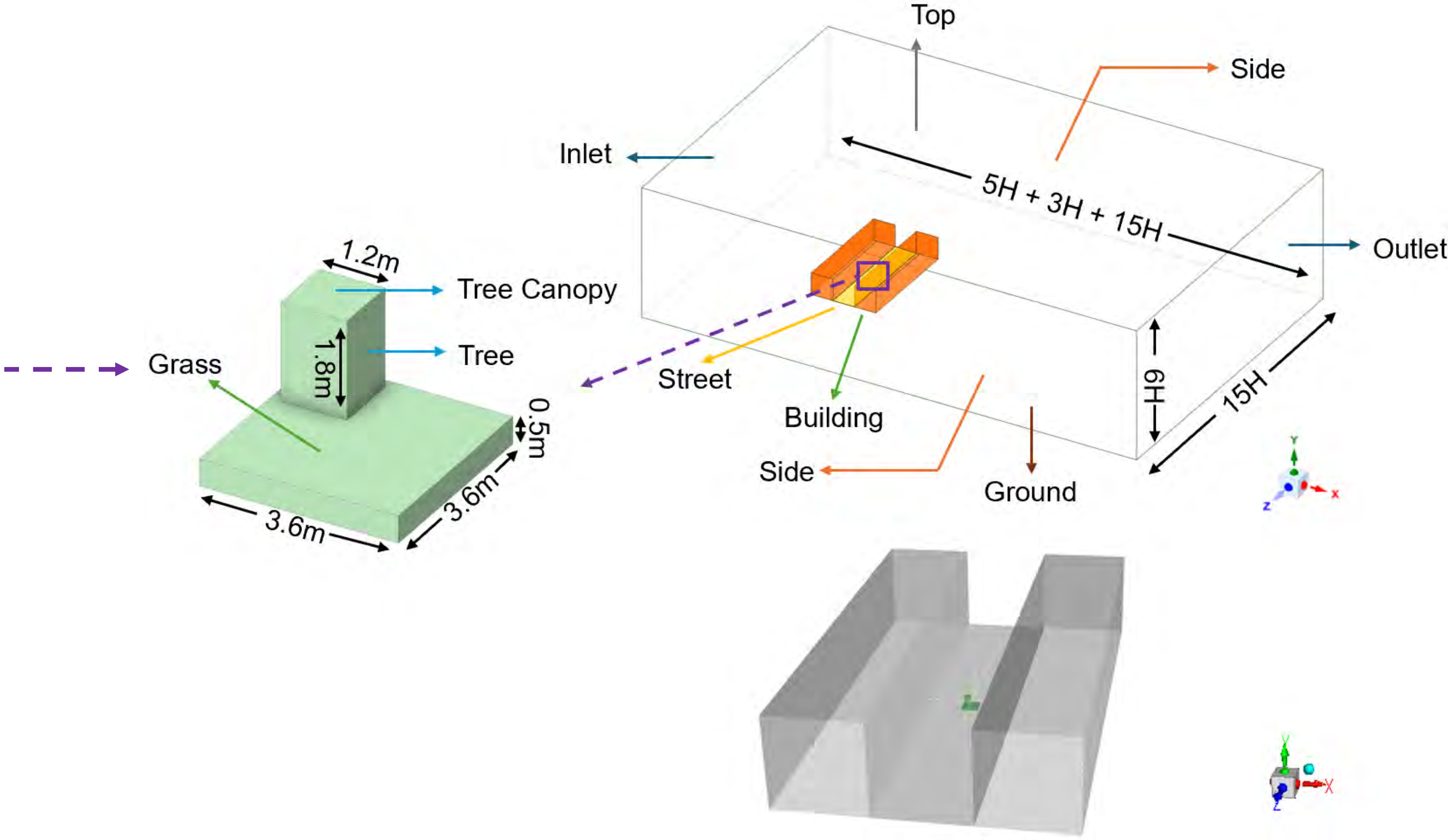


Ambient air
Above Plantabox
Plantabox substrate
Surface temp control
Temp (degC)
50
45
40
35
30
25
20
12:00:00 AM
6:00:00 AM
12:00:00 PM
6:00:00 PM
12:00:00 AM
Time


25.3 °C
28.8
21.1
FLIR


24.5 °C
31.3
22.3
FLIR

CFD simulation of the impact of Plantabox on UHI mitigation in an ideal street canyon



Numerical settings

Model selections

- Energy
- Steady state RANS, realizable K-epsilon (k-ε) turbulence model
- Standard wall function
- Radiation

  >> Discrete Ordinates (DO)

  >> Solar loading

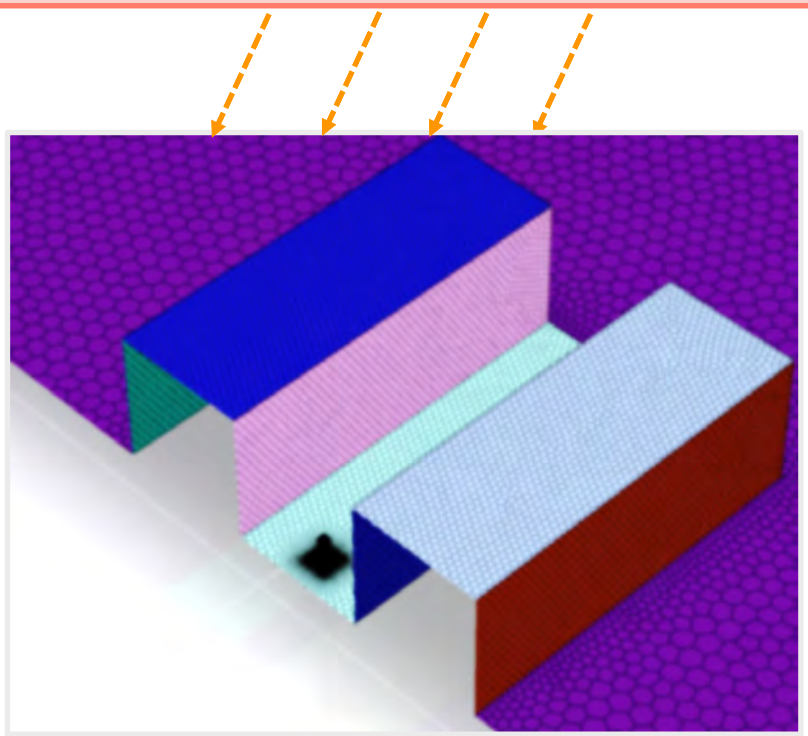
  >> Solar Tracing

Inlet velocity profile

- $U(y) = U_{ref}\left(\frac{y}{y_{ref}}\right)^{a}$
- $k(y) = (U(y) \times I_{in})^2$
- $\varepsilon(y) = \frac{C_{\mu}^{3/4} k(y)^{3/2}}{\kappa y}$

Solar radiation

- Values based on the solar calculator
- Date : February (Australian Summer)
- Weather: Fair weather condition



Approximation of vegetation canopy

- **Aerodynamic effect**
- **Evapotranspiration**
- **Shading effect**

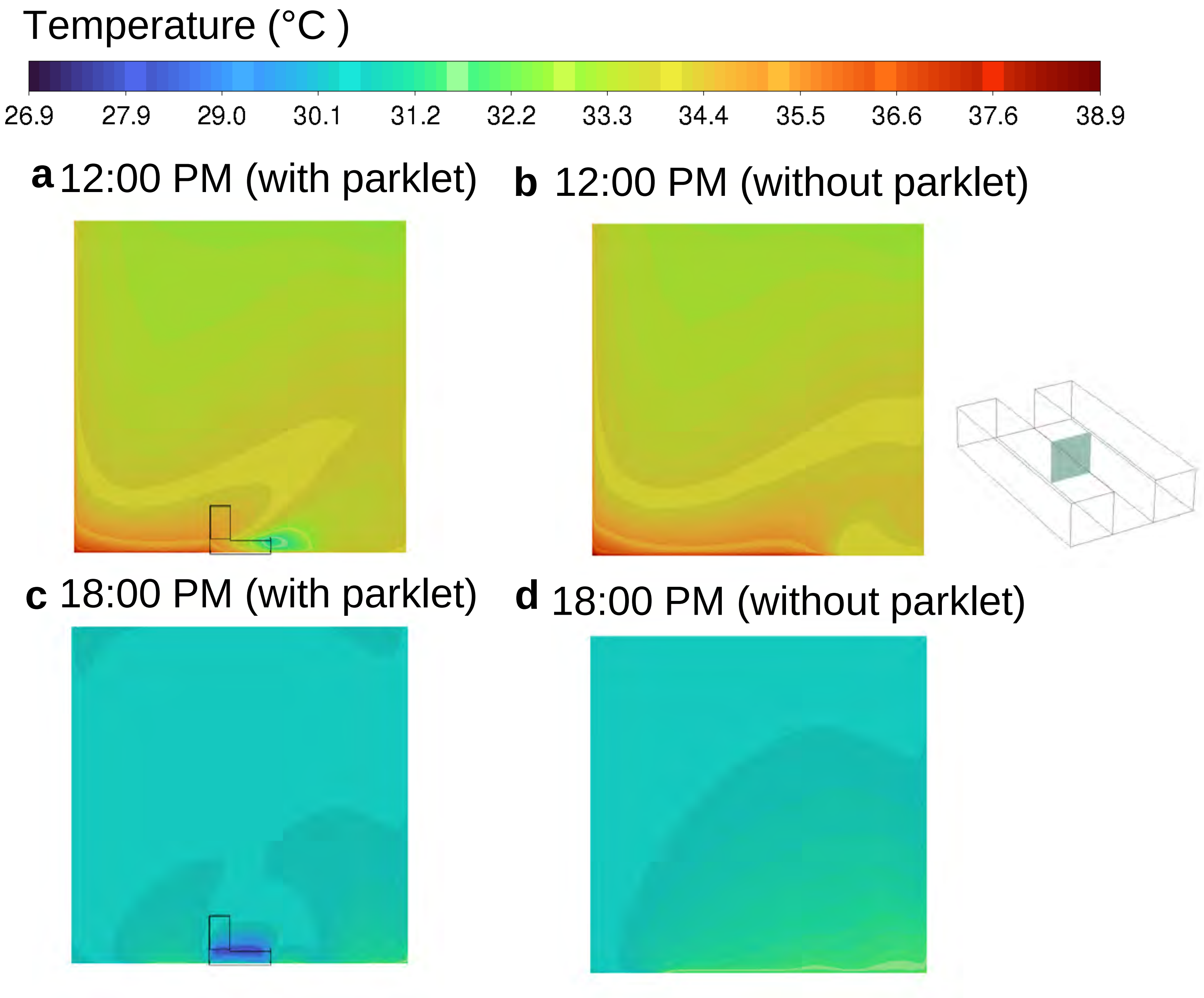
Heat transfer coefficient of walls

- Roofs: $h_c = 4.1V_R + 5.8$
- Other walls: $h_c = 4.1(2/3\,V_R) + 5.8$

Surface roughness height

- $K_s = \frac{9.793z_0}{C_s}$

Temperature contours on central x-y planes (z = 0 m)



Midday (12:00 PM):

•Maximum localized cooling of ~4.3 °C near the tray vegetation and ~1.5 °C at pedestrian height (Fig. a).

•Cooling extends towards the windward wall (~0.5 °C reduction), altering vertical thermal stratification above the parklet.

•A minor temperature rise (~0.1 °C) near the leeward wall is observed due to airflow blockage.

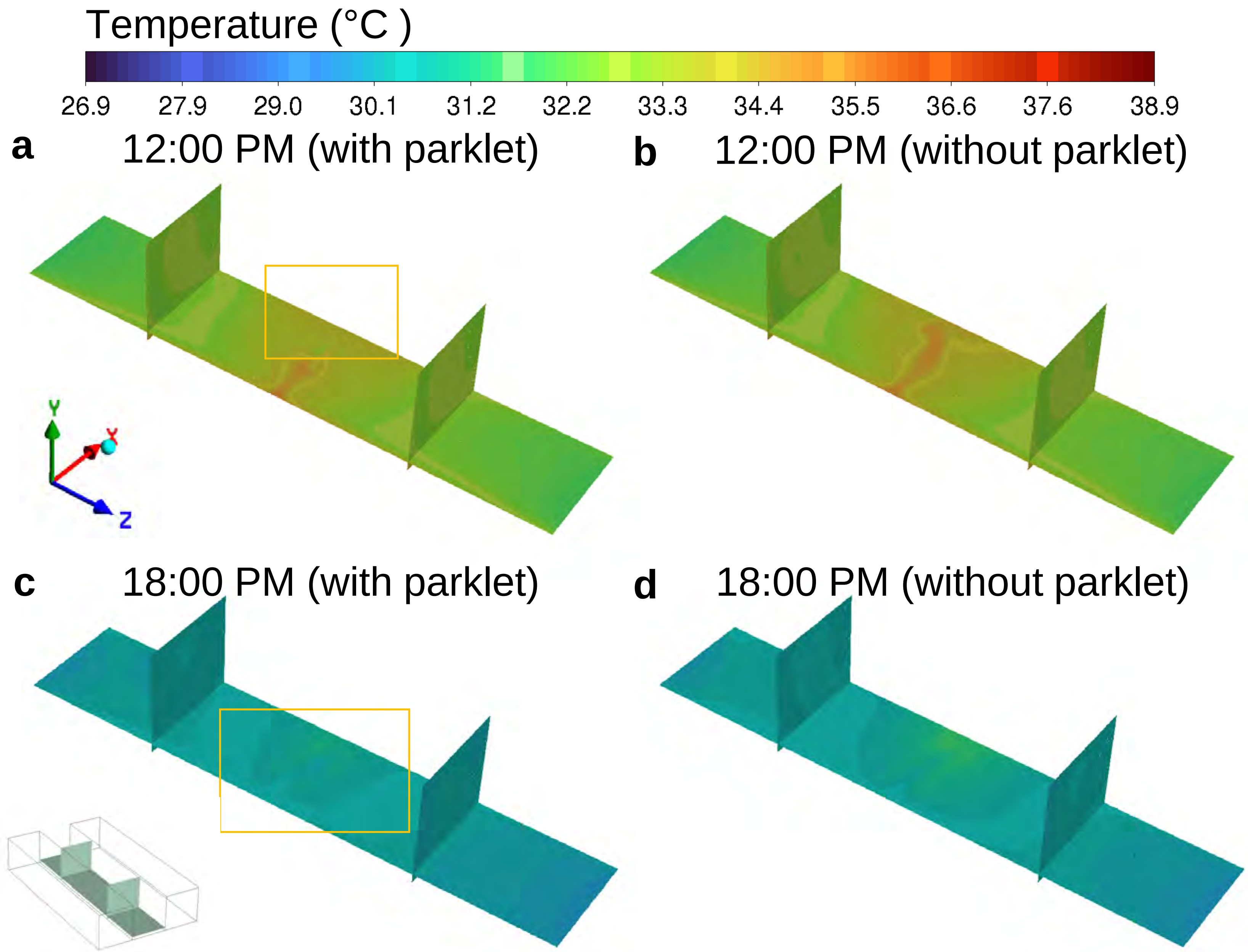
Evening (18:00 PM):

•The overall air temperature within the canyon is ~2 °C lower than at 12:00 PM, primarily due to reduced solar heating.

•The parklet continues to provide 1.5–2 °C cooling near the ground, with ~0.4 °C reduction at pedestrian height.

•Cooling effects are less pronounced than at midday, mainly due to weakened evapotranspiration as ambient temperatures drop (Figs. a and c).

Temperature contours on side x-y planes (z = ±25 m) and x-z plane at pedestrian height (1.75m)



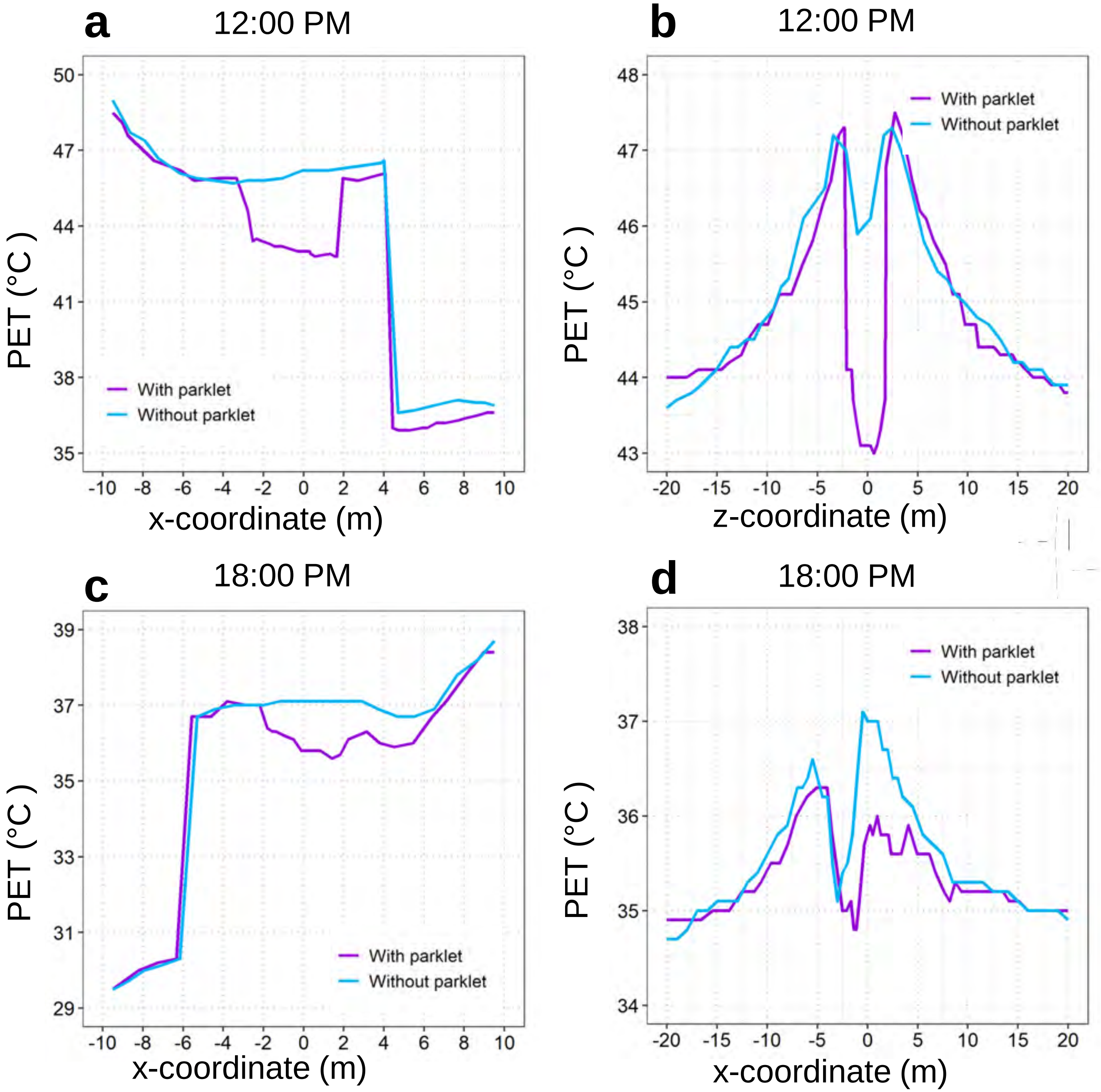
Midday (12:00 PM):

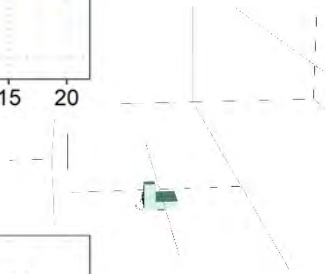
- A distinct cooling belt (~8 m wide) forms behind the parklet.
- Temperature reduction up to 0.3 ° C is observed above the parklet at pedestrian height.
- Cooling effects diminish near the street ends with minimal impact at z = ±25 m.

Evening (18:00 PM):

- More extensive lateral and vertical cooling.
- Cooling extends ±7 m laterally with a reduction of ~0.15 ° C along the z-direction (Figs. c & d).
- Peak cooling (~1.3 ° C) occurs around the grass tray, with airflow-driven lateral cooling due to a recirculation zone.
- While evapotranspiration weakens, shading and airflow alterations provide heat mitigation.

Physiologically equivalent temperature (PET) profiles along two lines at pedestrian height





Midday (12:00 PM):

•Maximum PET reduction of 3.4°C occurs above the parklet

•Shading significantly reduces mean radiant temperature, playing a dominant role in PET reduction.

•PET drops by ~10 °C near the windward wall.

•Cooling is less pronounced in the street center.

•Along the z-direction, PET reduction is limited to the parklet's influence area

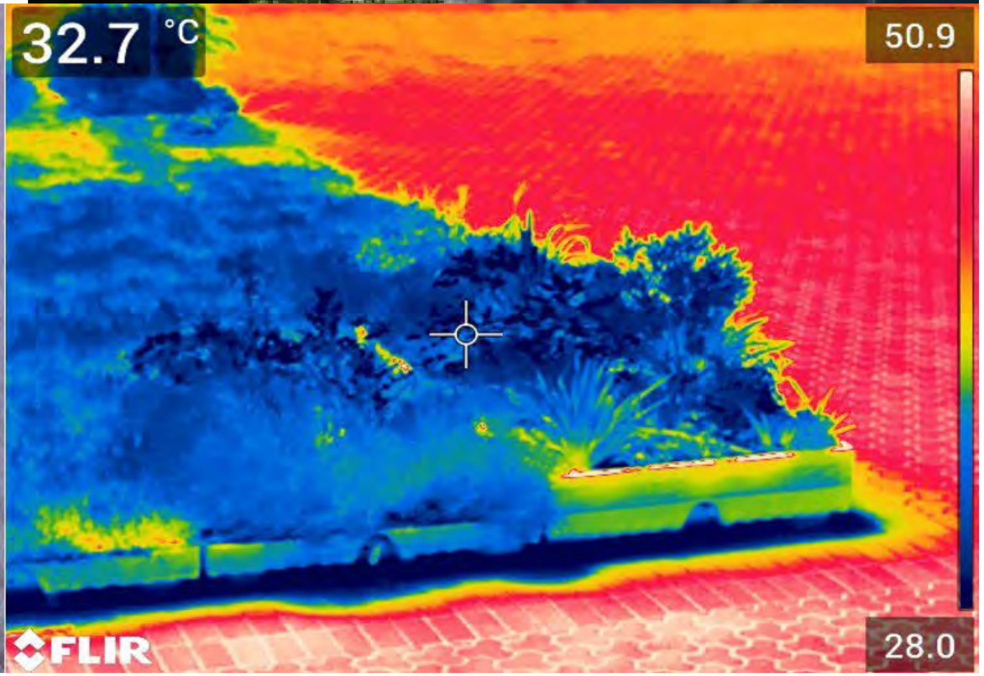
Evening (18:00 PM):

•Lower air and surface temperatures shift the thermal sensation class from "strong heat stress" at midday to "moderate heat stress" near shaded walls.

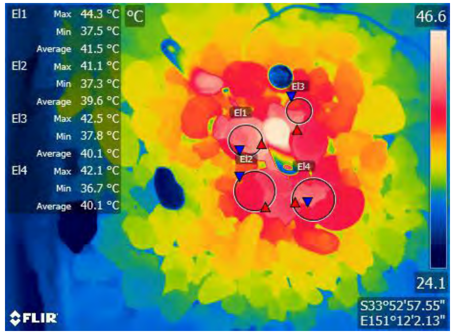
•Maximum PET reduction of ~1.1 °C .

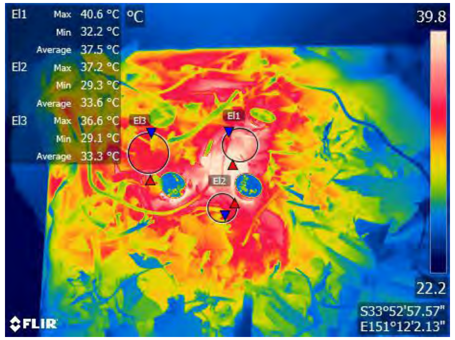
•Cooling effect extends up to 6 m along the positive x-direction.

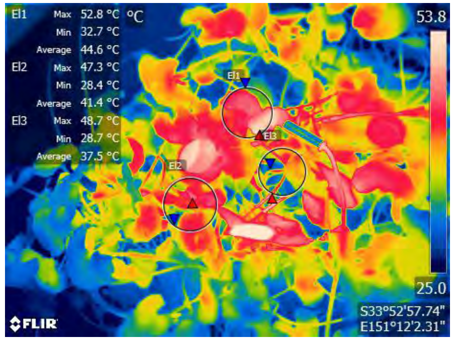
Phase 2



Substrate and Plant Library - Experimental Design





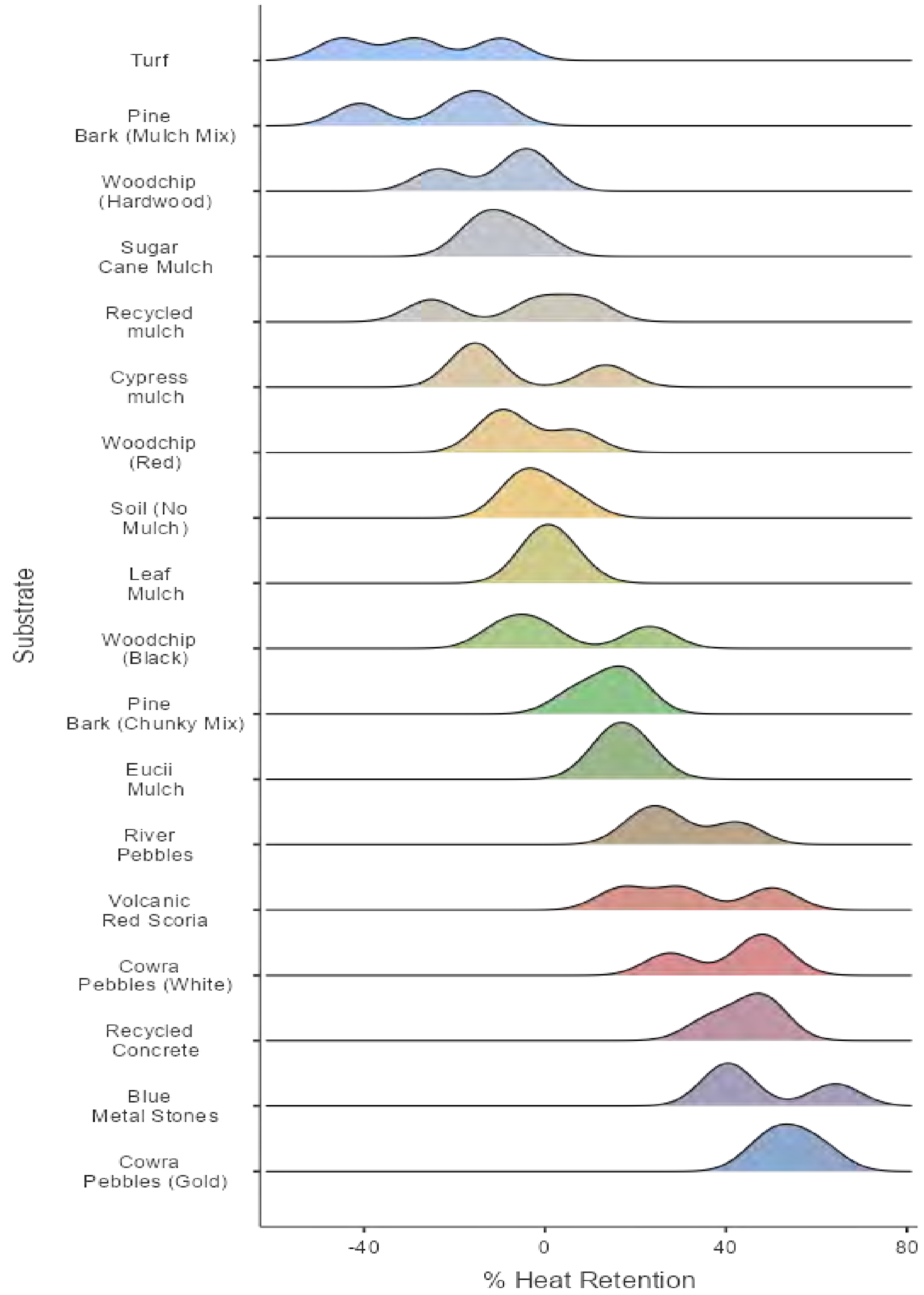


275W heat lamp
> 60ºC high heat exposure to simulate high heat stress environment

Substrate and Plant Library
Assessed under controlled conditions to compare performance
10minute acute exposure to high heat stress, 10 minute cooling period
Procedure run in triplicate

FLIR Imagery
FLIR images taken at 2minutely intervals
% Heat Retention calculated for all plant and substrate samples under the same heat stress conditions

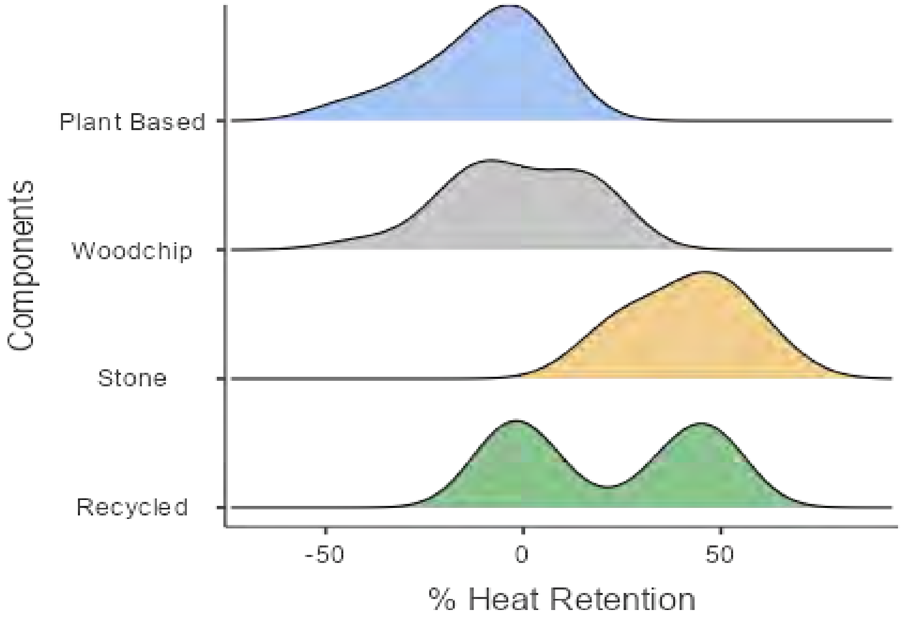
Substrate Library - Results



Turf outperforms all substrates - lowest % heat retention

One way - ANOVA shows statistically significant difference between substrate % heat retention. *Post hoc* comparisons illustrate:

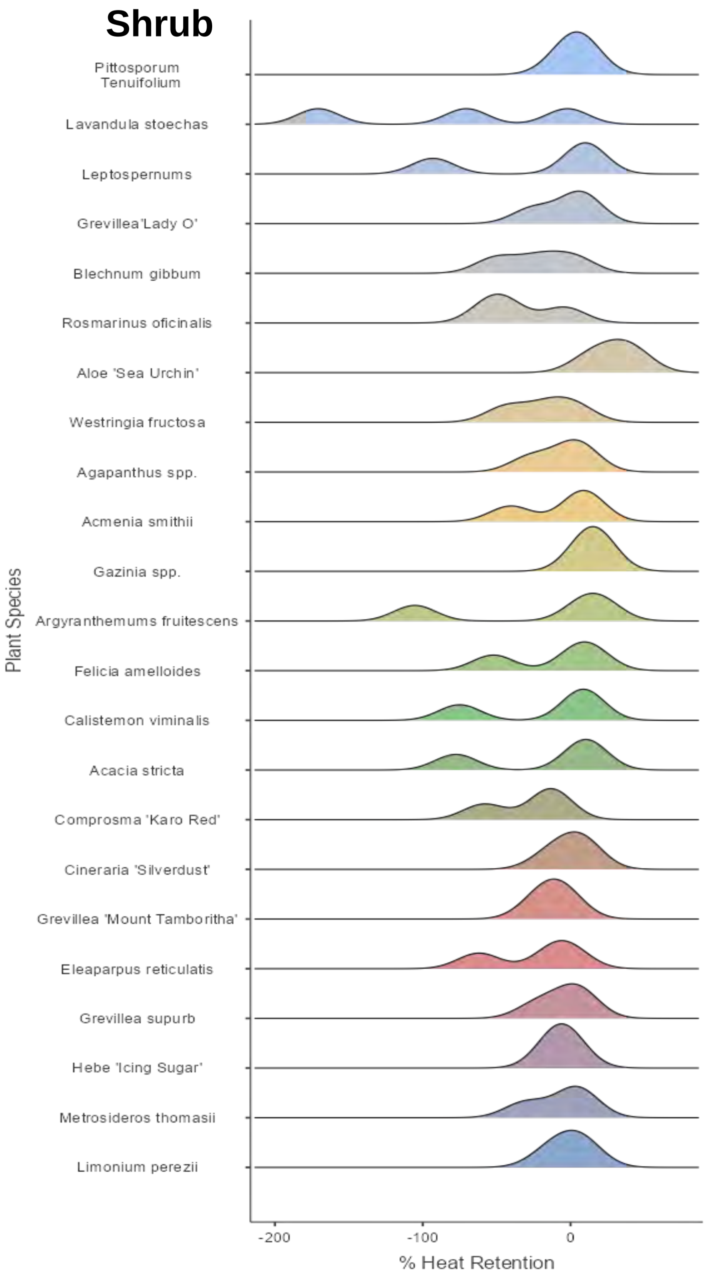
- % heat retention in top 10 substrates (Turf – Black Woodchip) have similar performance, no sig. difference
- % heat retention significantly greater in bottom 8 substrates (Pine Bark Chunk – Cowra Pebbles)

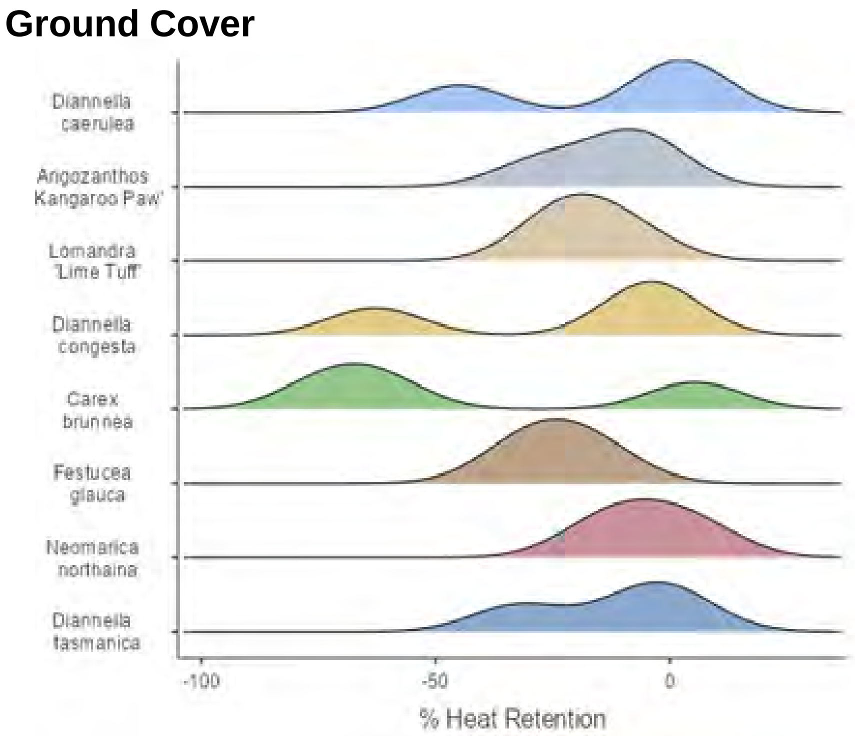


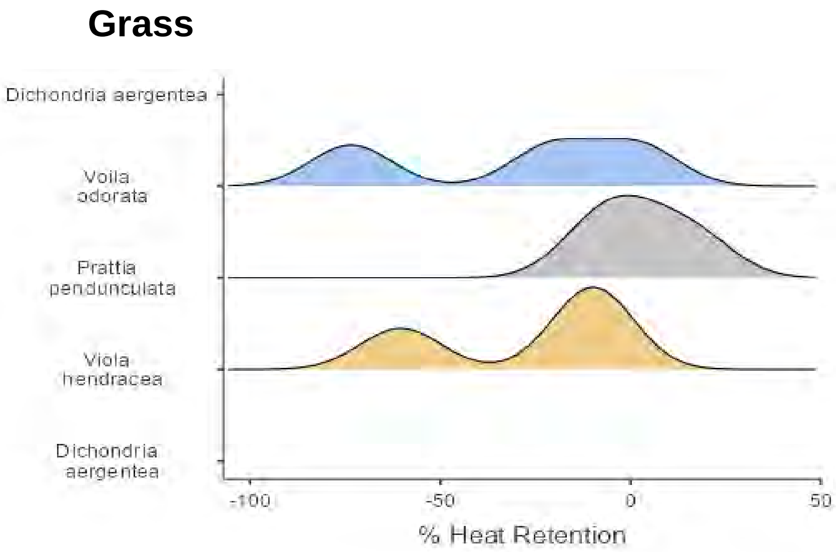
One way - ANOVA shows sig. dif. in % heat retention between component material. *Post hoc* comparisons illustrates:

- Plant Based and Woodchip based substrates perform similarly (low % HR)
- Stone and Recycled Construction Material both have sig. higher % HR

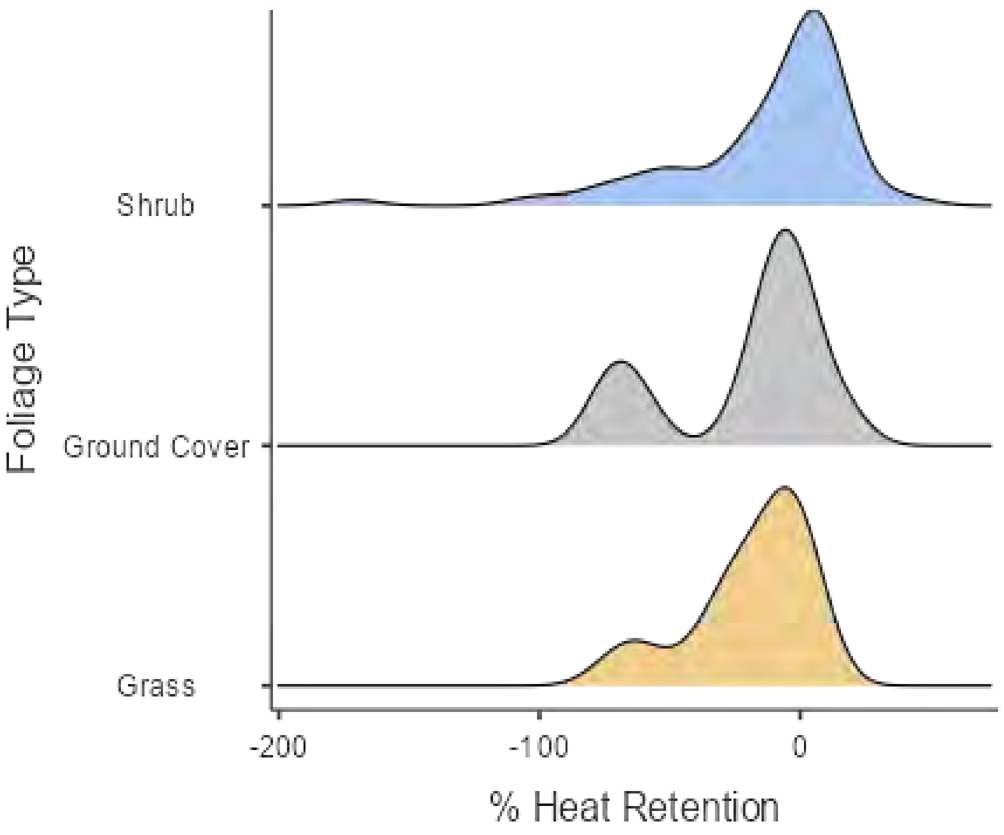
Vegetation Library - Results







Vegetation Library - Results



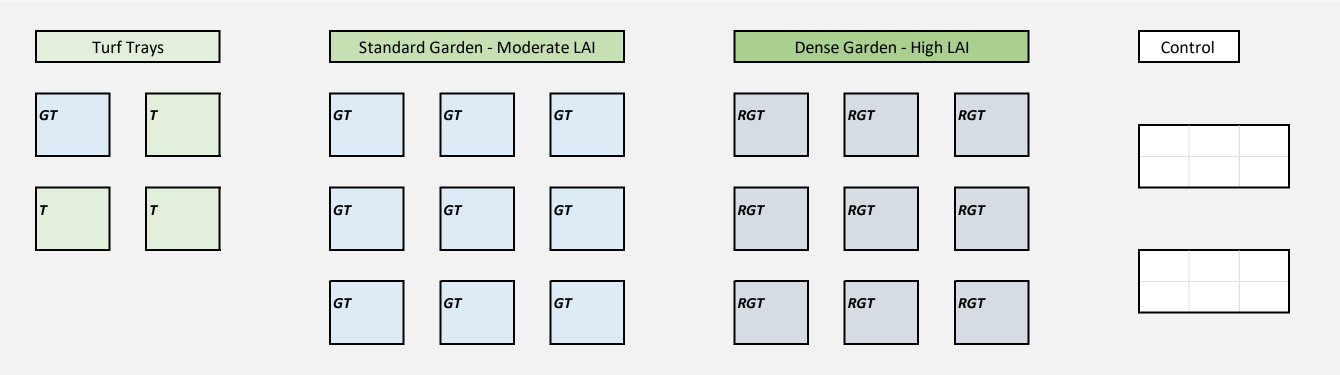
When all plant species catagorised by foliage type, both ground cover and grass found to significantly outperform shrub type.

TAKE HOME MESSAGE

All vegetation has lower % heat retention than all substrates (exception : turf & pine bark mulch mix)

Therefore: maximise vegetation cover over substrate exposure

Rooftop Plantabox Case Study – Experimental Design

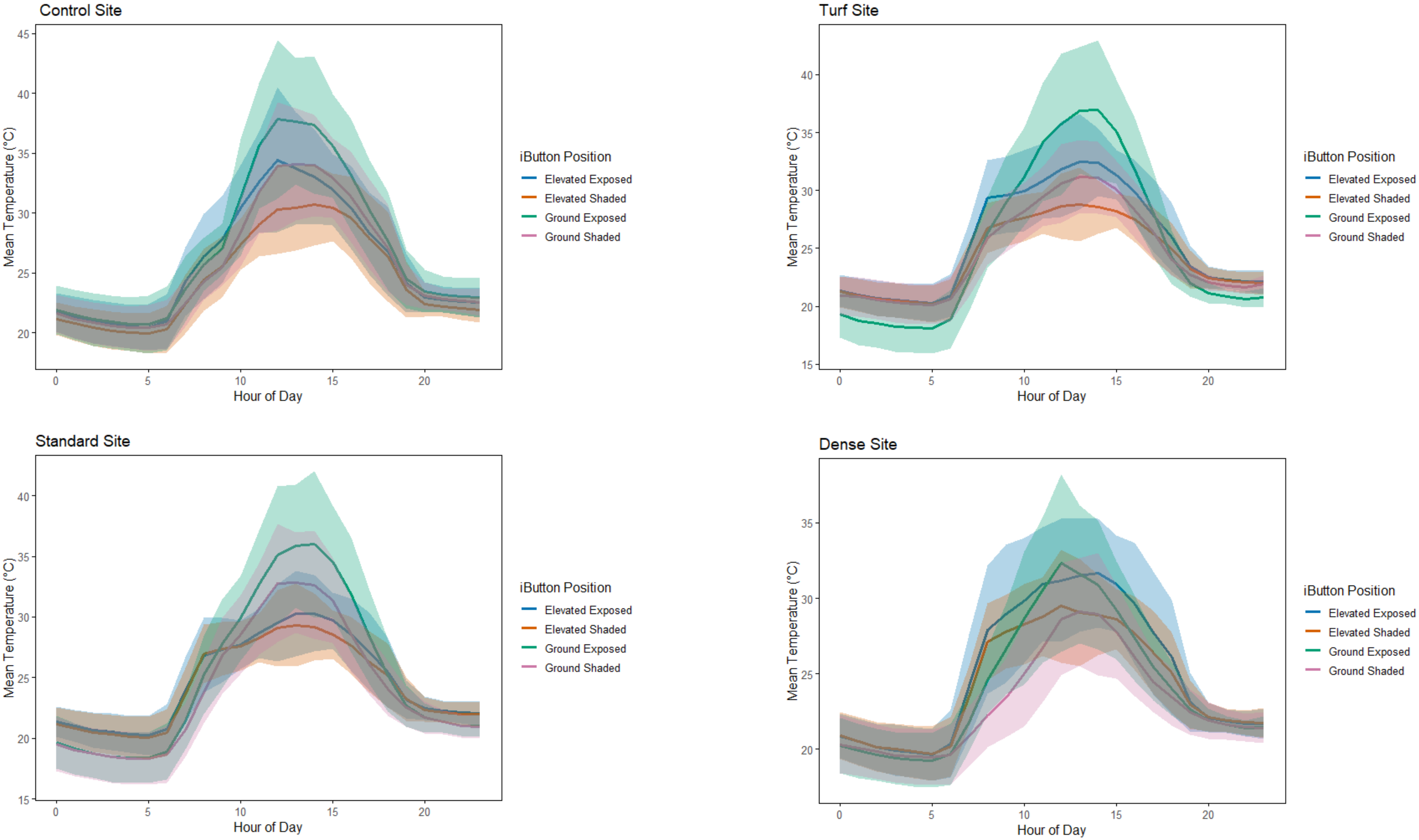


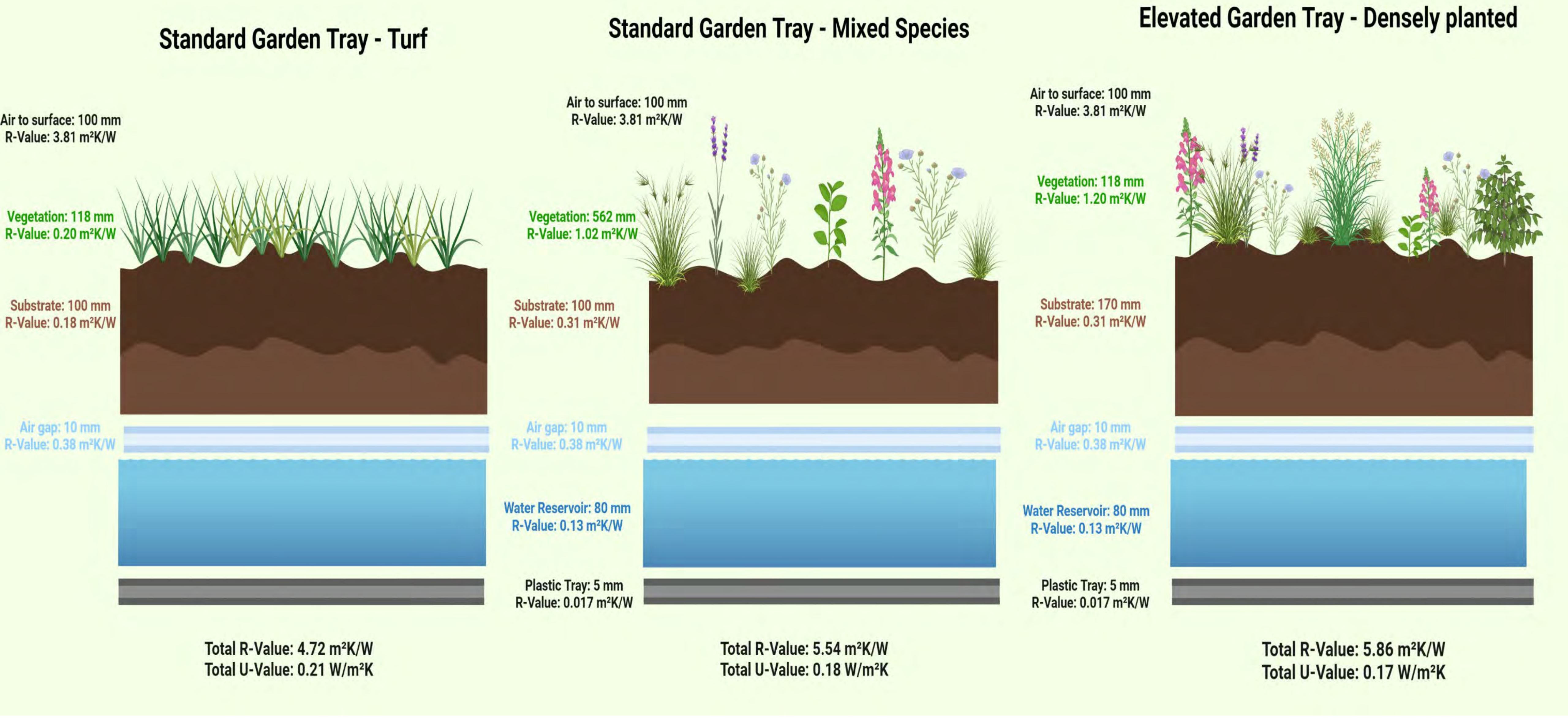
Use of continuous temperature-loggers (iButtons) positioned within the greenroof. (pictured: iButtons within the standard garden trays across a vertical gradient to assess vertical cooling effect)

Thermal Performance Assessments

- ***shade** effect* (difference between exposed and shaded temperatures at surface and elevated spaces above the greenroof)
- ***lateral** effect* (difference between central greenroof temperatures and ambient temperatures lateraly beyond the greenroof garden bed)
- ***vertical** effect* (difference between substrate, surface and elevated ambient temperatures above the greenroof)
- ***heat flow** effect* (difference in temperature moving through the greenroof – insulation effect)

Rooftop Plantabox Case Study – Shade Results





Energy simulation of a 3-storey office indicated 71% electricity reduction for cooling throughout summer, and 38% annually.

Floating Gardens & cooling

26 March 2025

Transport

Transport

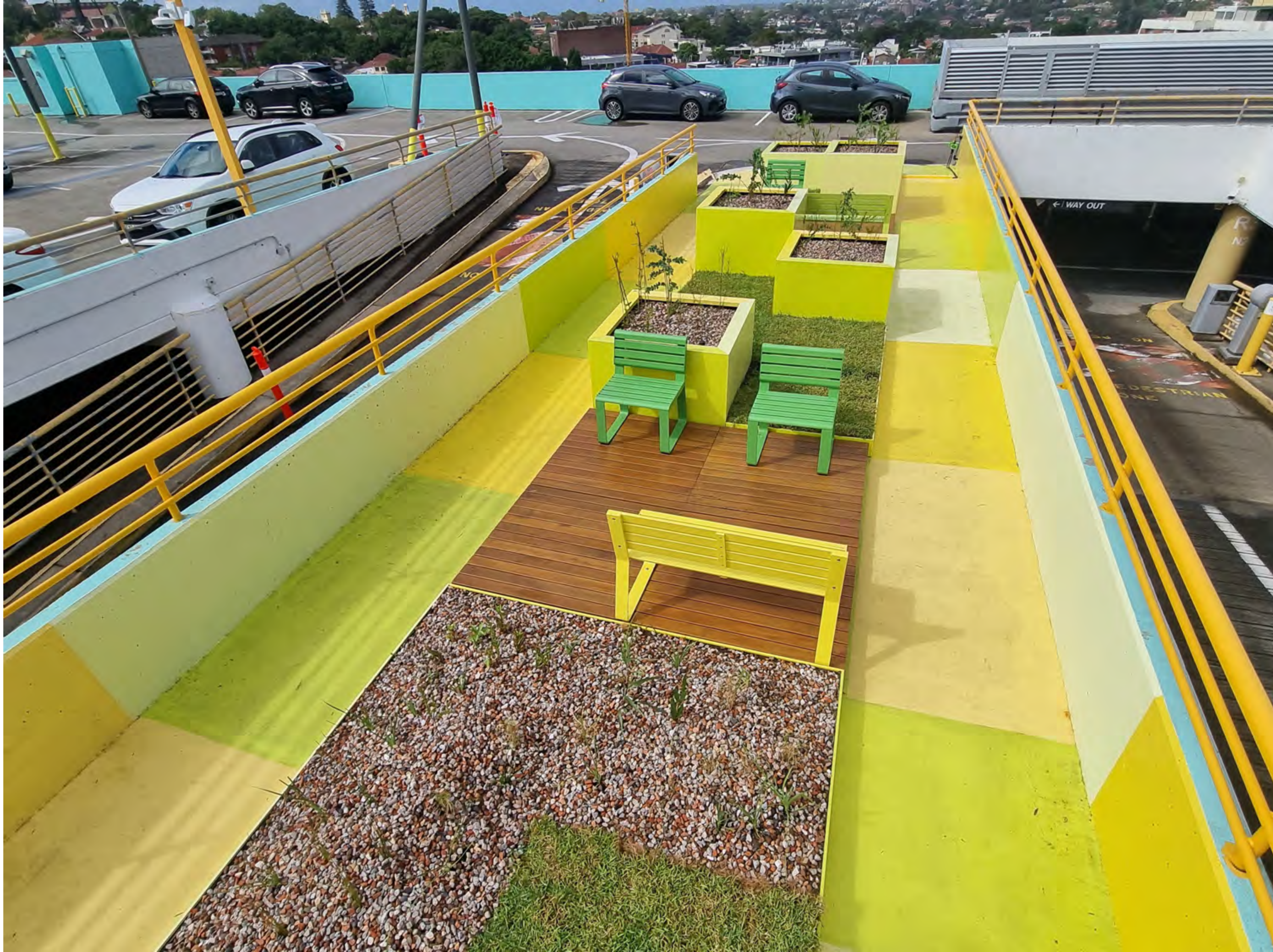
Transport

Horsham

Horsham

Horsham

Bondi Junction



Bondi Junction

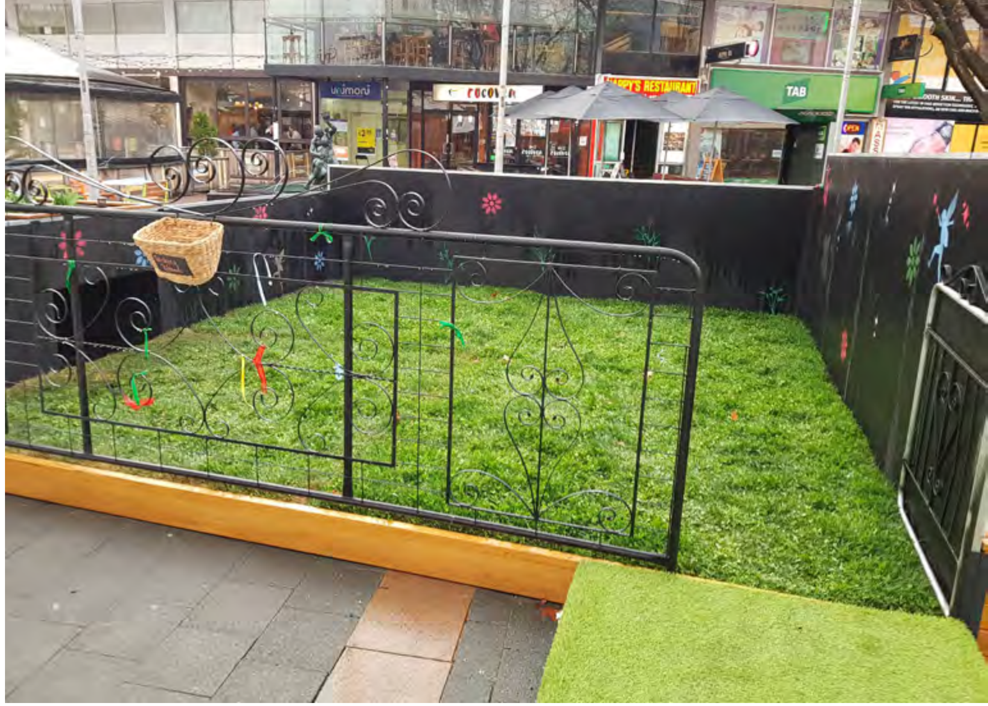
Mildura

Mildura

Canberra

Canberra

Canberra


TAB


Optometry
CAREMA CENTRE


SHOGUN TEPPANYAKI
JAPANESE RESTAURANT

Wollongong

Wollongong

Wollongong

Wollongong

Bendigo

Bendigo

Since 1897
Evans Shoes
INSTANT CASH
WE BUY GOLD & SILVER
KILLIAN'S WALK
OPEN

Ipswich

Sutherland

Maroubra

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Thank you

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Jake Bennett
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