Climate Change and Heat Mitigation in Southern Australian Cities

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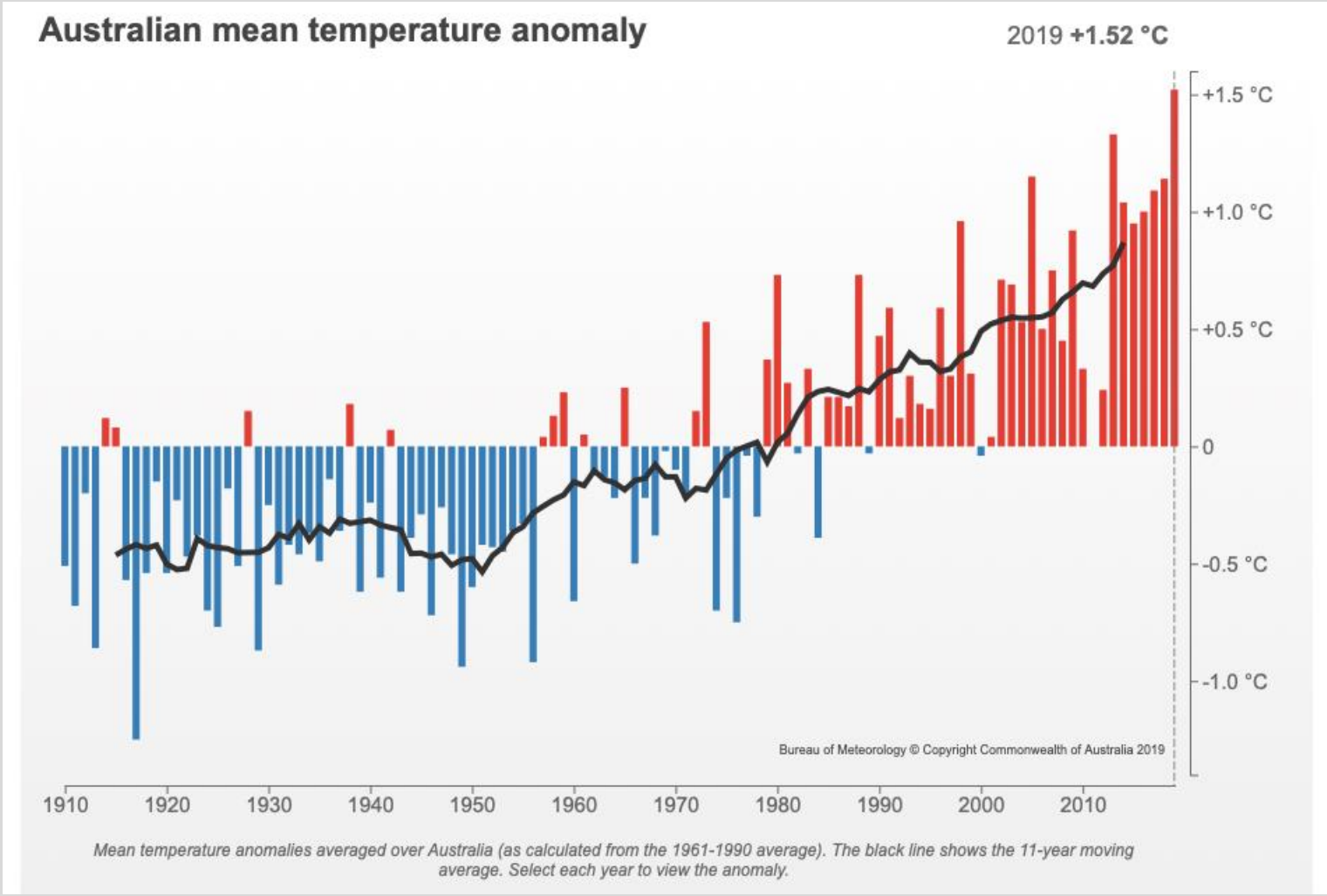
President, International Association for Urban Climate

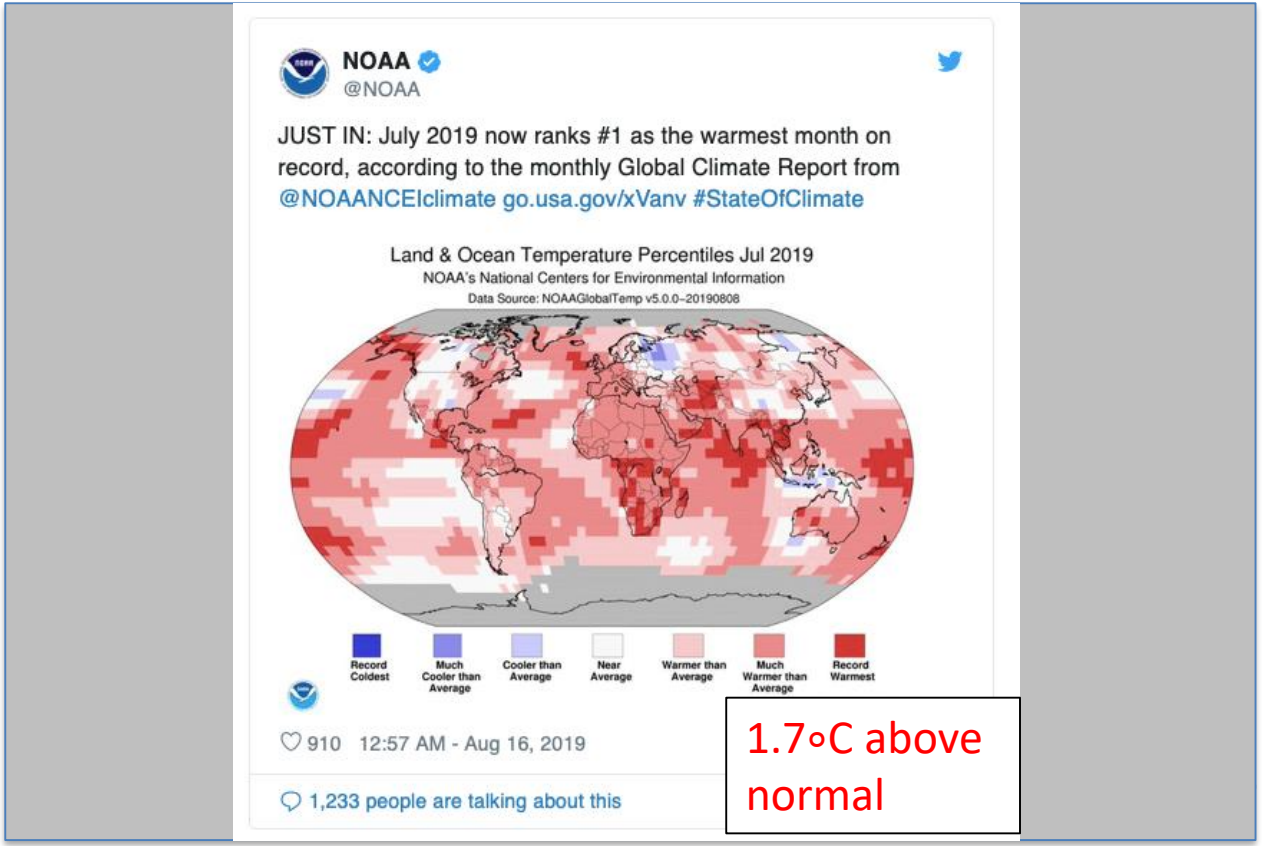
Lead Author, Working Group II, Adaptation, Mitigation and Vulnerability, IPCC 6th Assessment Report


Australian mean temperature anomaly
2019 +1.52 °C
+1.5 °C
+1.0 °C
+0.5 °C
0
-0.5 °C
-1.0 °C
Bureau of Meteorology © Copyright Commonwealth of Australia 2019
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Mean temperature anomalies averaged over Australia (as calculated from the 1961-1990 average). The black line shows the 11-year moving average. Select each year to view the anomaly.

And Globally!

- Clear evidence in the observational record
- On track for warming of 1.5°C by 2040
- 2016, 2018 and 2019 have all tracked >1.0 °C long-term average.
- July 2019 exceptional!

(IPCC, 2018; WMO, 2018)



Projected median frequency and 10-90th percentile range of extremely hot summer days (>40 °C) for Australian capital cities. (Source: (Webb and Hennessy, 2015)

	Current	2030 RCP4.5	2090 RCP4.5	2090 RCP8.5
Adelaide	3.7	5.9 (4.7-7.2)	9.0 (6.8-12)	16.0 (12-22)
Brisbane	0.8	1.2 (1.1-1.6)	2.1 (1.5-3.9)	6.0 (2.9-11)
Canberra	0.3	0.6 (0.4-0.8)	1.4 (0.8-2.8)	4.8 (2.3-7.5)
Darwin	0.0	0.0 (0.0-0.0)	0.0 (0.0-0.2)	1.3 (0.2-11)
Hobart (>35°C)	1.6	2.0 (1.9-2.1)	2.6 (2.0-3.1)	4.2 (3.2-6.3)
Melbourne	1.6	2.4 (2.1-3.0)	3.6 (2.8-4.9)	6.8 (4.6-11)
Perth	4.0	6.7 (5.4-7.5)	9.7 (6.9-13)	20.0 (12-25)
Sydney	0.3	0.5 (0.5-0.8)	0.9 (0.8-1.3)	2.0 (1.3-3.3)

What can we do to increase the resilience of our cities in the face of climate change?

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Our work in Australia has focused on <u>two</u> areas in order to address this concern

1. Improved public heat warnings and emergency services preparedness to save lives

2. Finding solutions to make our cities cooler to save lives and protect city infrastructure from extreme heat

Improved public heat warnings and emergency services preparedness to save lives

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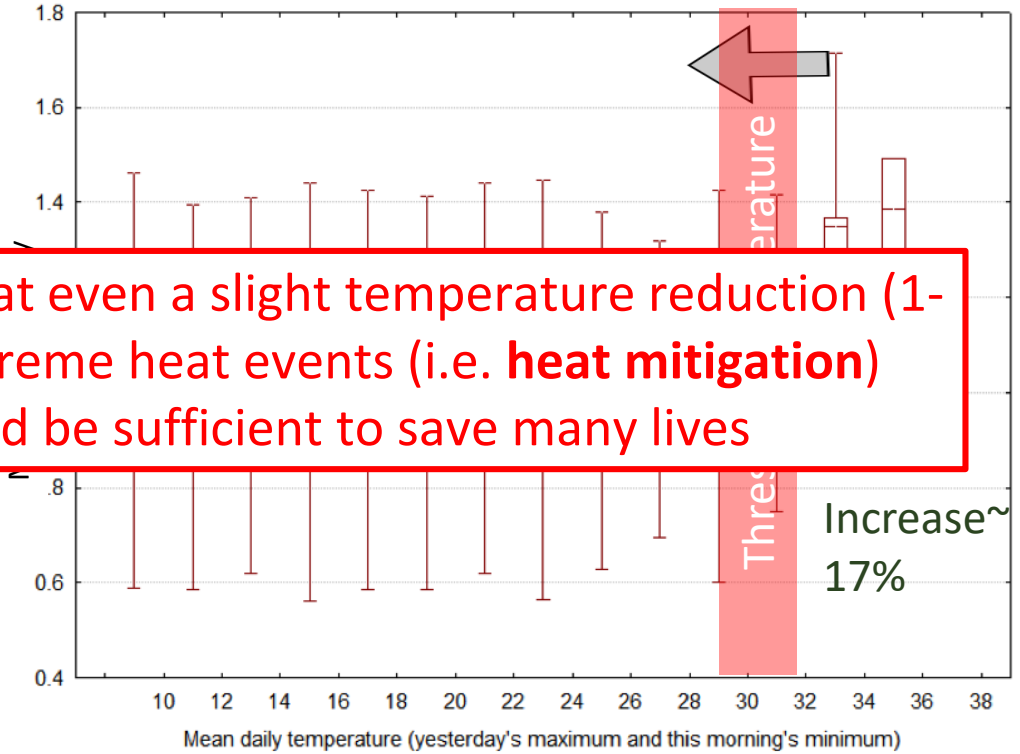
Melbourne – Heat Threshold for Excess Deaths in >64

MDT of 30°C = (40°C+20°C)/2

Suggested that even a slight temperature reduction (1-2°C) in extreme heat events (i.e. **heat mitigation**) would be sufficient to save many lives



Nicholls, Skinner, Loughnan and Tapper, 2008

Mapping the Heat Vulnerability Index in Australian Cities

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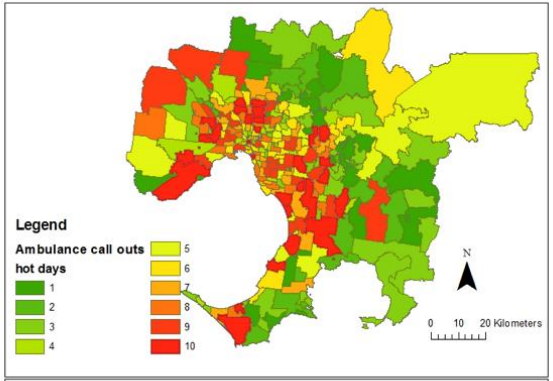
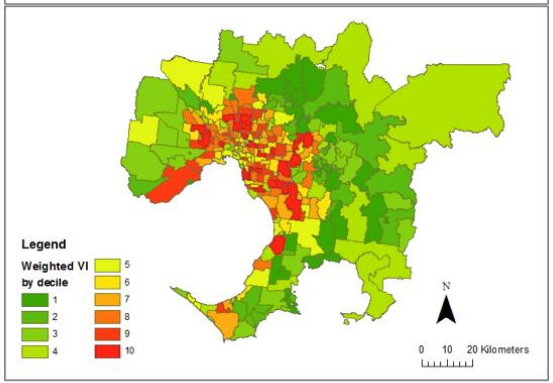
- Critical ris
  priori' fro
- Extreme h
  defined fo
  associate
  identified
- Statistics
  risk factor
  vulnerabi

Melbourne, Australia

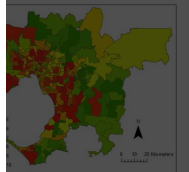


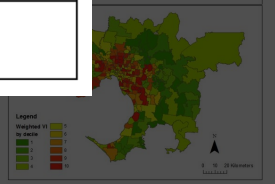


Risk factor
Age (0–4, 65+)
Aged care faciliti
SES
Urban design (n dwellings)
Single-person ho
Need for assista disability)
Population densi
Ethnicity
UHI
Land cover
Accessibility to e service

sources
BCP Table 1
artment of Health and Ageing
SEIFA Table 3
BCP Table 31
BCP Table 22
BCP Table 17
BCP Table 1
BCP Table 12
DIS (Terra) Land surface Temperature & sivity Monthly L3 Global 0.05° CMG
Meshblock
gle maps

nperature & 5° CMG





Loughnan, Tapper, et al 2013

Cooling Cities: The key research question and approach

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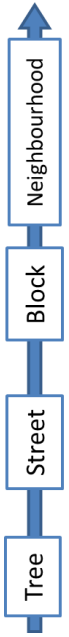
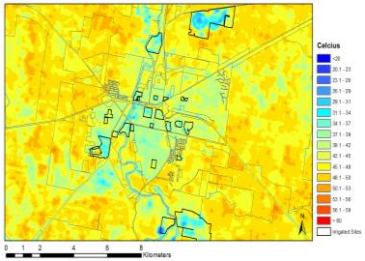
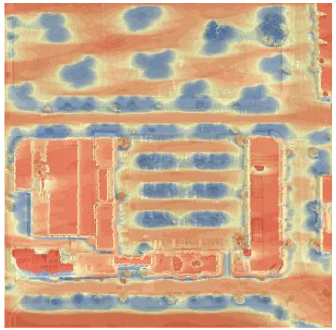
"What are the key technologies and approaches required to cool Australian (and many global cities) to adapt to climate change and save lives in extreme heat?"



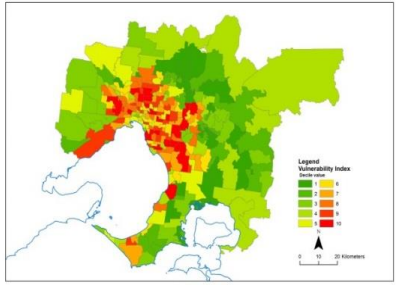
Observations



Remote sensing



Modelling



Database mapping

Our Multi-Scale Research Approach – focused on Irrigated Green Infrastructure

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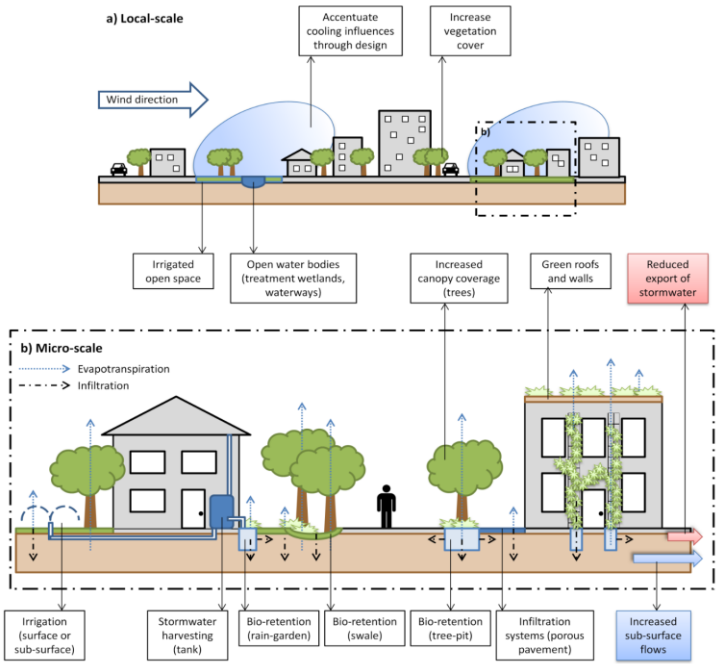
Role of water and green infrastructure → Reduce local-scale air temperature → Limit heat-health impacts

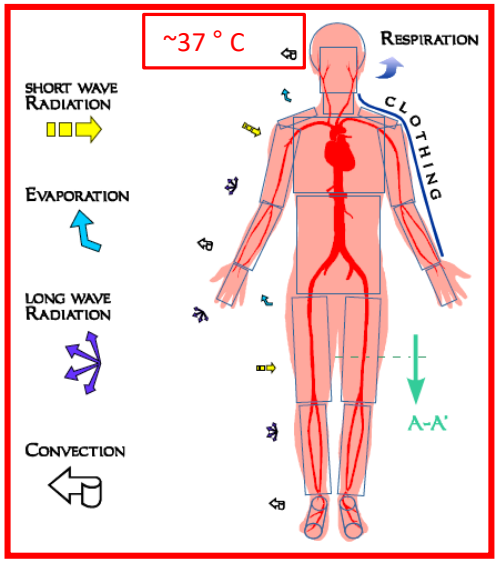
↓

Reduce micro-scale air temperature and *radiant* temperature

↓

Improve human thermal comfort





Coutts, Tapper, Beringer, Loughnan, Demuzere (2013)

Irrigated Green Infrastructure – Using Stormwater Harvesting

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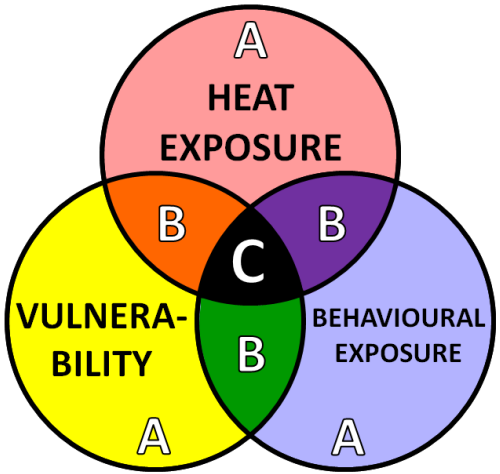
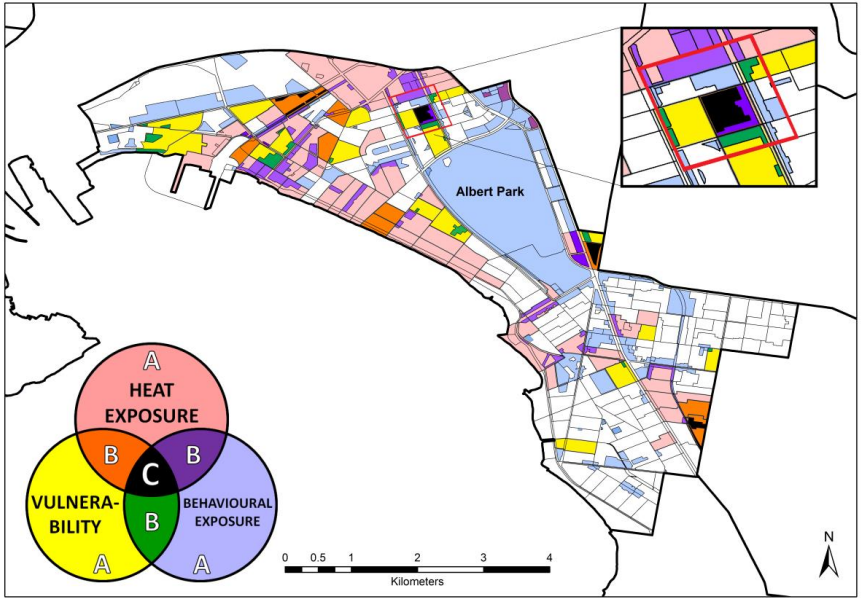
‘Climate’ tool for prioritising the implementation of WSUD/GI

- **Limited funds for implementation**
- **Where to target increases in canopy cover?**
- **How do we deliver the biggest ‘bang for buck’?**
- **We need to prioritise!**

“The current evidence base does not allow specific recommendations to be made on how best to incorporate greening into an urban area” (Bowler et al 2010)



Norton, B. A., Coutts, et al. 2015. Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. Landscape and Urban Planning, 134, 127-138.



Summer Cooling at Microscale – *specific publications*

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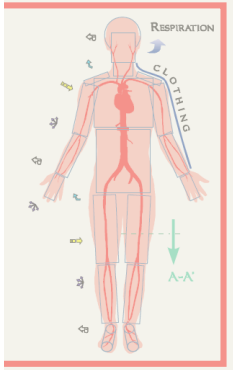
Nature of Treatment	Sum
Precinct tree cover *(modelling))*	Doubli… mean …d by
Street trees (E-W *(observat…*	…p to 4°C
Indiv… *(obser…*	…g within and below …t events, along with up to …e reduction
Green roo…	…rface temperature reduction, with little …t away from the roof.
Rain garden	Up to 1.5°C air temperature reduction to 1x the diameter downwind; up to 25°C reduction in surface temperature

At microscale we can achieve air temperature cooling of 1-2°C, and "feels like" cooling of 7-10°C



Irrigation (surface or sub-surface)

Stormwater harvesting (tank)

Bio-retention (rain-garden)

Bio-retention (swale)

Bio-retention (tree-pit)

Infiltration systems (porous pavement)

Increased sub-surface flows

Summer Cooling at Local Scale (Suburb to City

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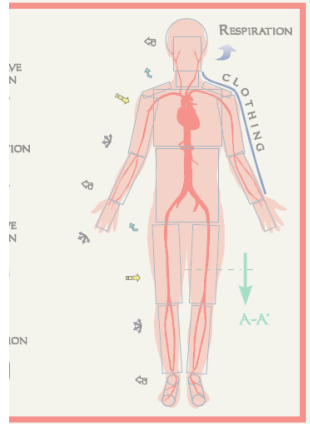
Nature of Treatment	Summer Cooling Provided
Inner city park – lightly irrigated *(observational)*	1°C average air temperature co… more in extreme heat events); UTCI ("fee… of up to 10°C in shade
City Botanical Gardens – irrigated *(observational)*	Up to 3.5°C… extreme hea…
Large urban lake *(observational)*	…1x
Suburban *(mo…*	…during extreme heat …n and up to 2.5°C cooling with …p to 20°C surface temperature
Ci… inc…	…to 1°C air temperature reduction for tree cover increase from 20 to 40% (spatially averaged 0.3°C). Cool roofs and irrigation add a further 1.3°C cooling.
City-w… …tation fraction *(remote sensing)*	6°C cooling in summertime surface temperatures with an increased vegetation fraction from 0.2 to 0.8.

Botanic Garden Irrigation
Heat wave – up to 3.5°C ai… temp
(Lam, Gallant and Tapper, 2017)

Suburban heat wave
Low/mod irrigation - ~0.5°C temp
Very heavy irrigation - up to 2.5°C air temp
Up to 20°C surface temperat…
(Broadbent, Coutts, Tapper a… Demuzere, 2017)

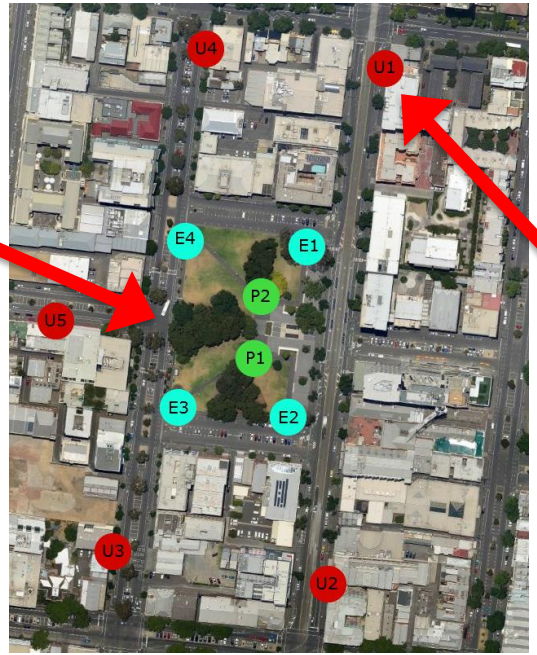
Park cooli…
Typical – l…
UTCI - up t…
(Motazedi…

Equivalently at local scale we can achieve air temperature cooling of 2°C+



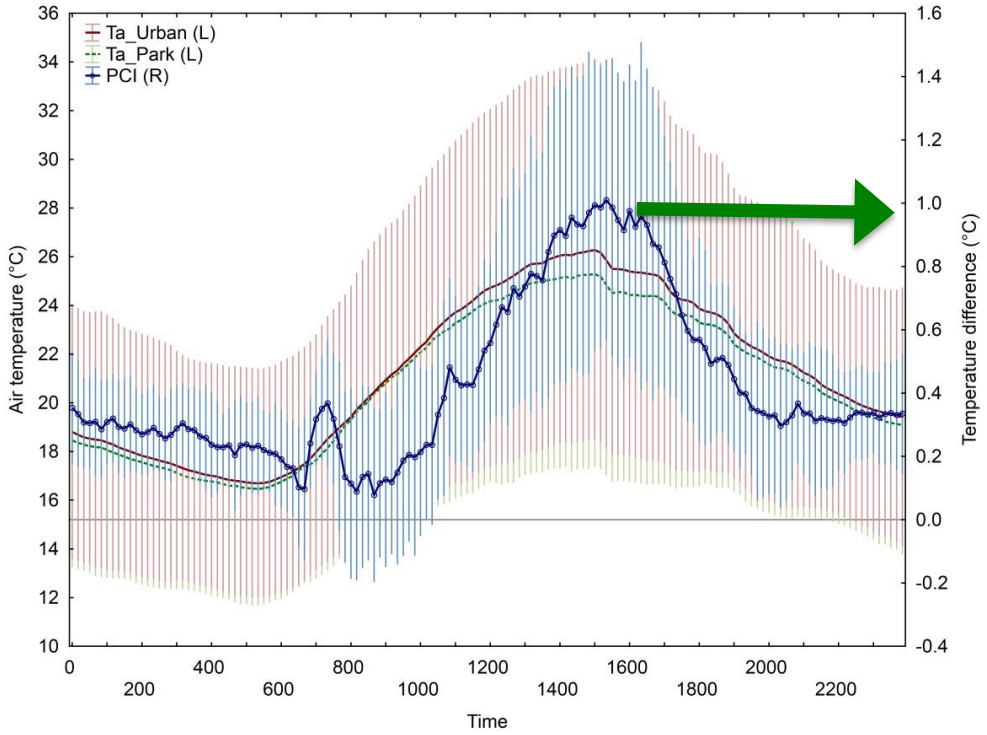
Case Study 1– Role of a Small Inner-City Park in Urban Cooling (light irrigation)

Lincoln Park
Melbourne

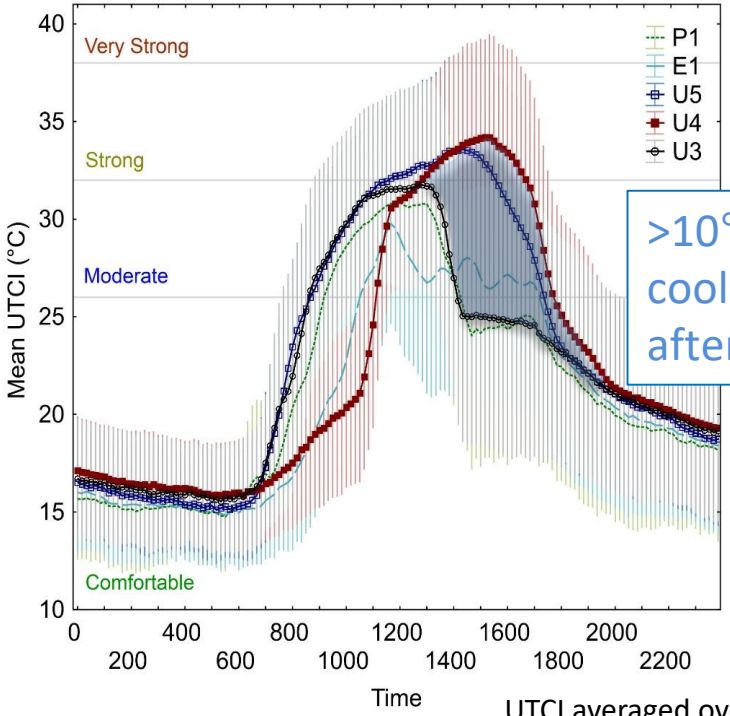


Observations and Modelling

Lincoln Park Melbourne – Mean Summertime Cooling of ~1°C (4 months data)



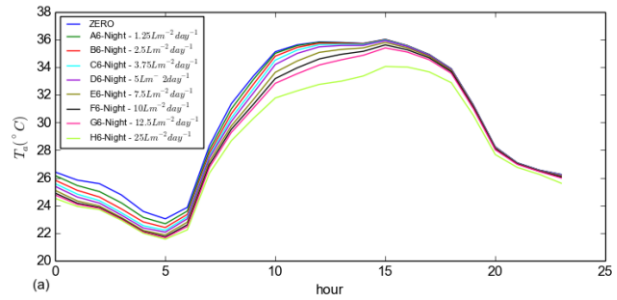
Lincoln Park Melbourne – Role of a Small Inner-City Park in Improving Thermal Comfort



>10°C UTCI cooling late afternoon

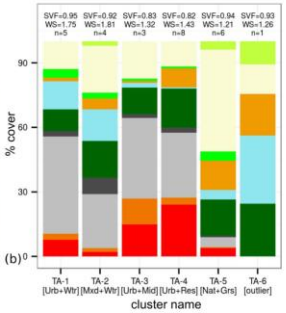
UTCI averaged over summer 2013-14 for the stations inside the park and the surrounding canyons with different solar access – large improvement in comfort in park.

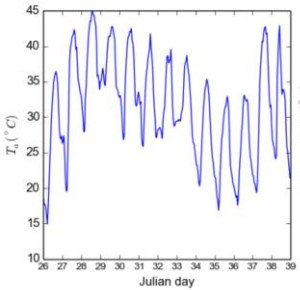
Case Study 2 - Landscape irrigation for cooler cities and suburbs – Suburban-scale Modelling, Adelaide, Australia

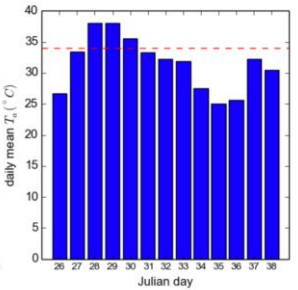


Broadbent, Coutts, Demuzere and Tapper (2017)

- Used an observation-validated SURFEX model to assess impact of irrigation during 2009 heatwave
- A range of irrigation scenarios simulated







Landscape irrigation - Adelaide, Cooling Patterns

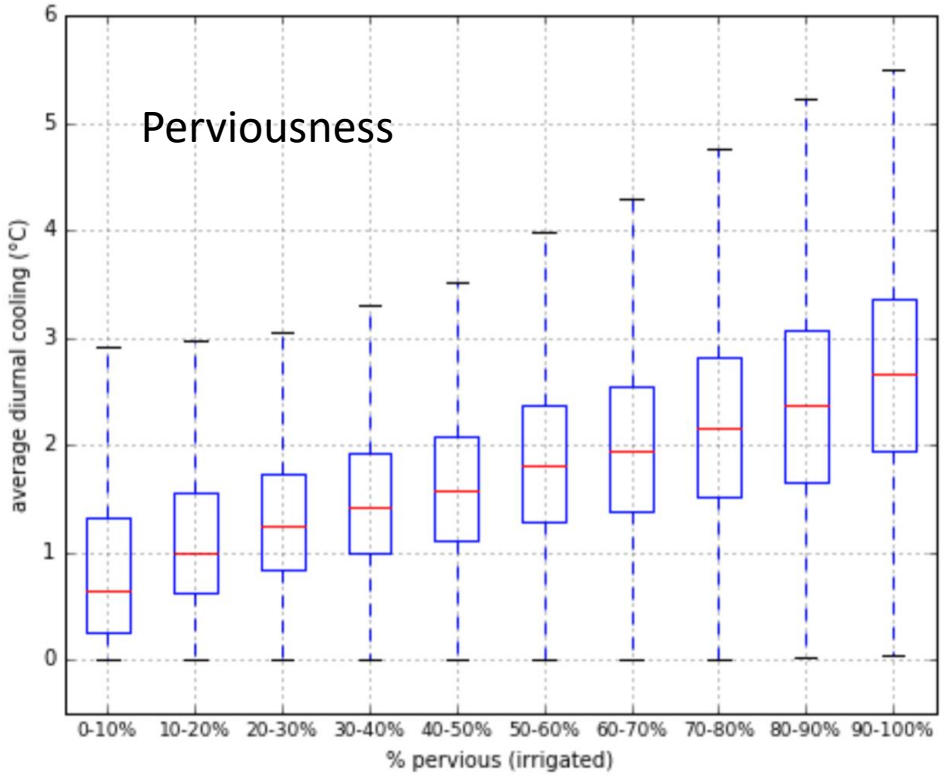


Figure 7:

irrigation.

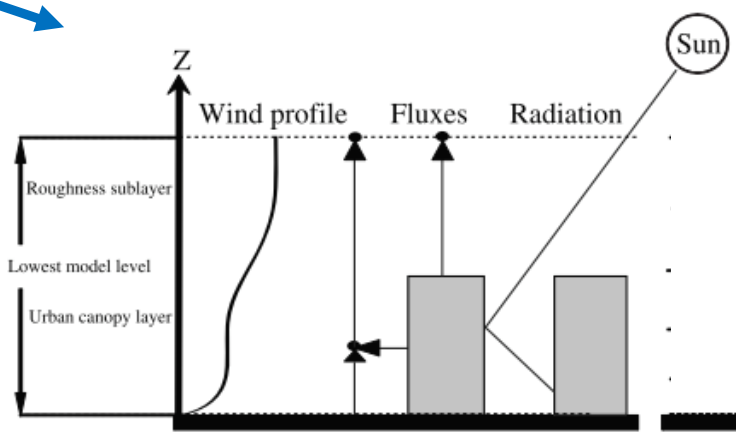
Broac

Case Study 3 – Citywide Cooling From Vegetation, Irrigation and Albedo Change

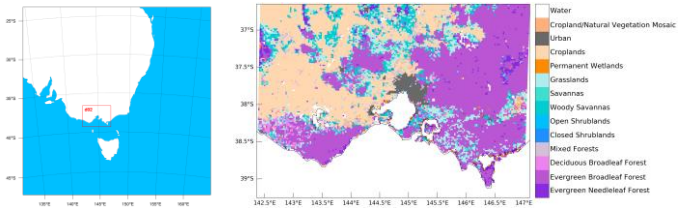
Weather Research Forecasting Model V3.8.1
Noah land surface scheme
Mellor-Yamada-Janjic boundary layer scheme
Dudhia shortwave radiation scheme
Kain-Fritsch cumulus physics scheme
Rapid Radiative Transfer Model longwave radiation scheme
WRF Single Moment 5-class microphysics scheme
Monin-Obukhov surface similarity scheme

coupled to

Single Layer Urban Canopy Model

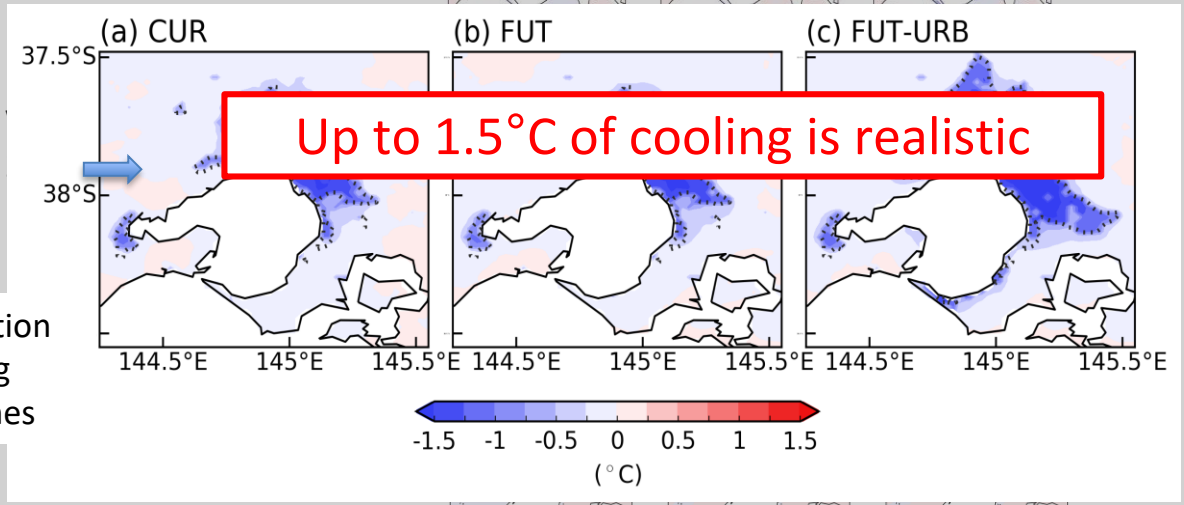


SLUCM



City-wide Cooling in Melbourne – Heat Wave
Current and Mid-Century (with Climate Change)

Cool Roofs
0.2 → 0.7



Combination of Cooling Approaches

Jacobs, Gallant and Tapper (2018)

In Conclusion

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- Our work has shown that relatively small reductions in urban temperatures can produce large benefits for human health and city infrastructure
- The work, focused on southern Australian cities with dry-summer climates suggests that cooling in the order of 2°C or more can be achieved using irrigated vegetation (green infrastructure) supported by storm water harvesting
- The cooling provided by irrigated green infrastructure can be enhanced with a range of other heat mitigation approaches including albedo modification to provide critical “head room” for otherwise unavoidable global warming.