URBAN HEAT MODELLING FOR DECISION MAKING

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Abstract

Understanding and mitigating urban heat has the potential to save lives as well as give other co-benefits such as increased walkability, connectivity and liveability. The field of urban heat modelling has grown in recent years to help with quantifying the urban cooling benefits from a range of measures such as street trees, irrigation, green roofs, cool roofs and water bodies. Quantifying the cooling benefit allows people to make decisions regarding tree placement, species selection and the built urban environment, to understand the economic benefits, set tree canopy targets and inform the design process for new developments.

Introduction

Urban areas tend to have a different microclimate from rural areas. They are often hotter and drier due to a phenomenon known as the urban heat island effect. Factors that contribute to the urban heat island effect include (Figure 1) (Oke, 1987) :

- Dense dark surfaces such as bitumen on roads and building materials absorb heat and then emit it increasing the air temperature
- Street geometries and building morphology can also contribute to local urban hot spots where a lack of shade and high exposure to the sun can increase the heat accumulation in urban areas
- A lack of vegetation and surface water reducing their shading and evaporative cooling effects
- Heat from air conditioning units, traffic and people themselves

Australia is one of the most urbanised countries in the world with 86% of the population living in cities (World Bank, 2019) and the urban heat island effect poses a danger to human health through raising the temperature in cities, particularly during heatwaves. Heatwaves, known as the "silent killer", have caused more fatalities in Australia since 1890 than bushfires, floods, earthquakes, tropical cyclones and severe storms combined (Hughes et al., 2016). This is due to often vulnerable people such as young children and the elderly suffering heat stress and hyperthermia from elevated body temperatures, due to their poorer ability for thermoregulation. Heatwaves in Australia are expected to become hotter, longer and more frequent (Cowan et al., 2014). Therefore, the combination of the urban heat island and heatwaves raises the risk of deadly heat stress in cities in the current and future climate (Fischer et al., 2012).

Microclimate modelling can be used to map urban heat across an area of interest, and to quantify the cooling benefit of heat mitigating measures such as trees, irrigation and cool roofs. Modelling also enables the quantification of human thermal stress, resulting in a holistic understanding of urban heat and its relationship with human health. This paper demonstrates multiple case studies where heat modelling has helped decision-making to plan and design cooler cities from the lot to city scale.

Case studies

Amaravati, India

The planned and growing City of Amaravati in India is expected to be "a blue green happy city". Heat modelling was conducted for the city based on master plans and zoning specifications. Hot spots were identified across the city while irrigation, street trees and green roofs were tested to see their effectiveness at mitigating heat (Figure 1). This gave information into the effectiveness of the mitigation strategies and influenced the design of the city.

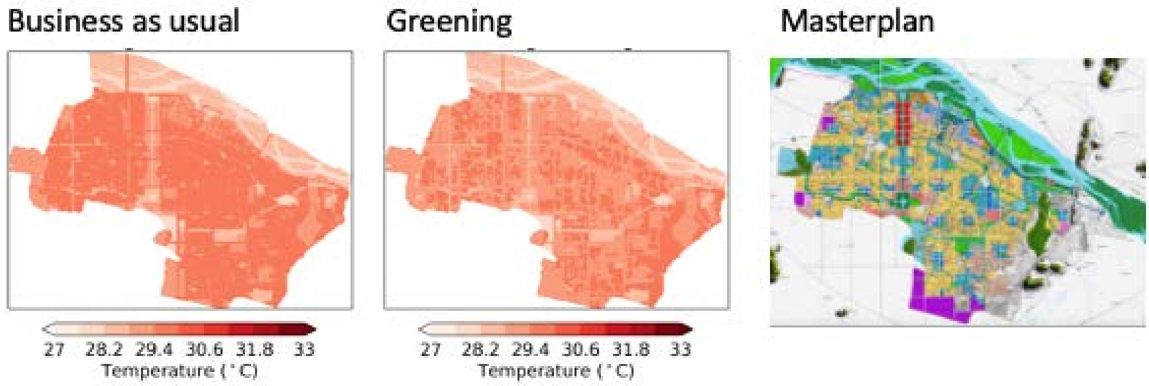

Figure 1. The modelled annual average air temperature in Amaravati (left), the temperature after the greening scenario of irrigation, street trees and green roofs was applied (centre) and the master plan the heat modelling was based on (right).

Proserpine, Queensland

Heat modelling was used to identify hot spots in the current and future climate of the town in Queensland (Figure 2). This will help with targeted heat mitigation campaigns and will be used for a heat reduction feasibility assessment.

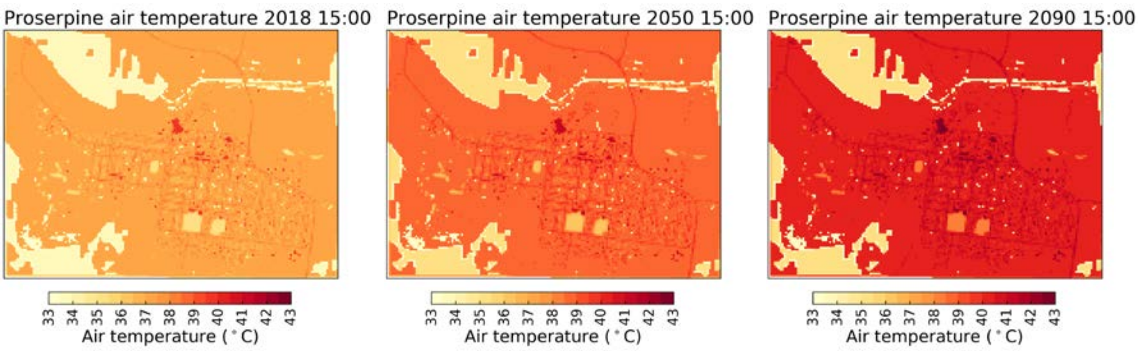

Figure 2. The modelled air temperature for Proserpine on an extreme heat day in the current climate (left), in 2050 with a high emissions climate change scenario (centre) and 2090 with a high emissions climate change scenario (right).

Minta Shadeway, Victoria

The Minta Shadeway maximises cooling for pedestrians by applying design principles that prioritises trees being placed where they can reduce the amount of direct solar radiation: wide open streets, east-west streets, east side of north-south streets, and north and west facing walls. Trees are planted in clusters to maximise the reduction in TMRT while still allowing the land to cool at night as hot air rises through the gaps.

To determine which are the best trees to plant in the shadeway, we modelled seven species of deciduous trees selected by a landscape architect for their cooling effect and assessed their water usage to determine which would be most effective at improving human thermal comfort on hot days. The *Quercus rubra* was found to produce high levels of cooling (Figure 3) while using minimal water.

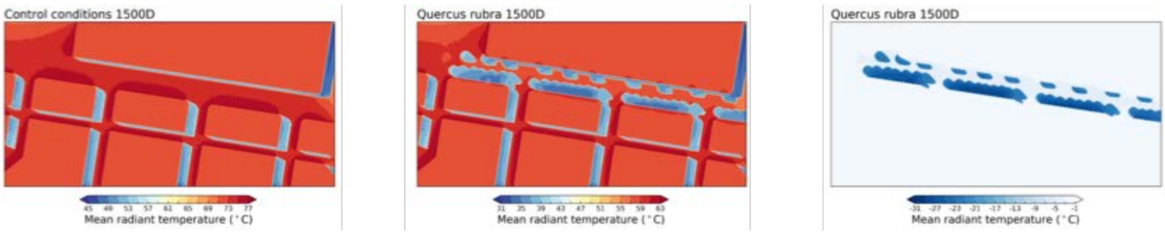

Figure 3. The modelled mean radiant temperature for the Minta shadeway on an extreme heat day with no trees (left), with the *Quercus rubra* planted on the shadeway (centre) and the difference between the scenarios (right).

Cairnlea, Victoria

A new development is being designed in western Melbourne which aims to be a ‘cool suburb’. We modelled nine different urban cooling scenarios testing various heat mitigation technologies such as cool roofs, cool pavements (Figure 4), water fountains, irrigation and trees to determine which produce the most efficient cooling in this designed landscape.

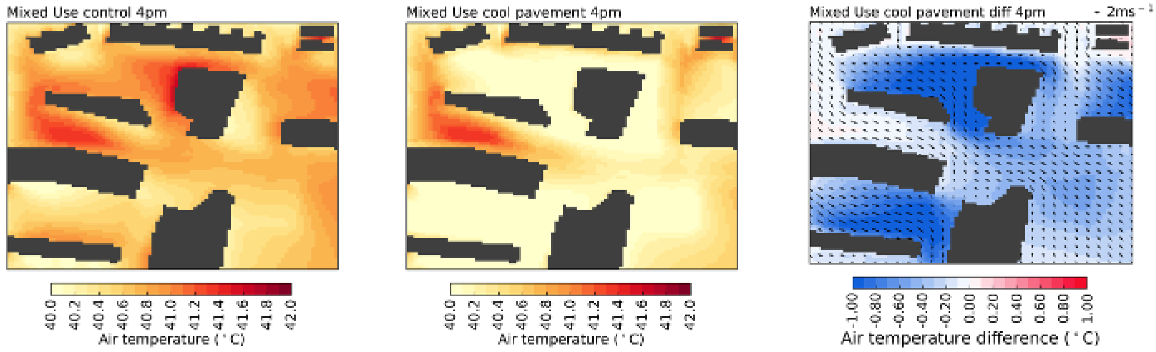

Figure 4. The modelled air temperature for the Cairnlea development on an extreme heat day (left), with cool pavements along all footpaths and carparks (centre) and the difference between the scenarios including the wind patterns (right).

South Creek, NSW

The new Western Parkland City in Sydney is designed to be ‘a city in its landscape’, restoring and regenerating the natural ecological and water systems. The intention is to go beyond a business-as-usual approach with innovative and flexible solutions that manage urban heat and water concerns.

Mosaic Insights reviewed the master plan for employment and residential precincts in South Creek and quantified the cooling benefits of each (Figure 5). The master plan included growing more trees to create shade, retaining water to irrigate grasslands, trees and rooftops, and reducing concrete surfaces.

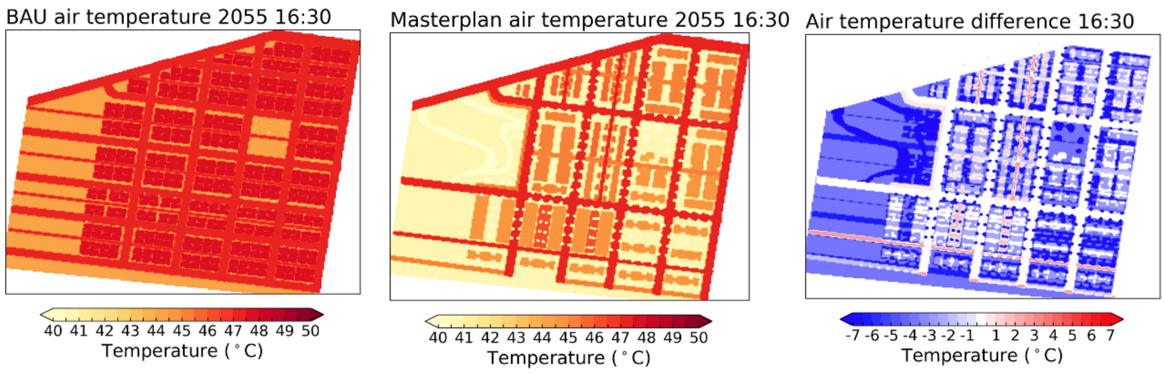

Figure 5. The modelled air temperature for a business as usual residential precinct on an extreme heat day (left), the master planned residential precinct (centre) and the difference between the scenarios (right).

Economic benefits, Victoria

The urban cooling benefits of various WSUD scenarios for a suburb in Melbourne were quantified and used as inputs for an understanding of the economic benefits (Figure 6). The results showed that in the high WSUD scenario households could save $1500 per year.

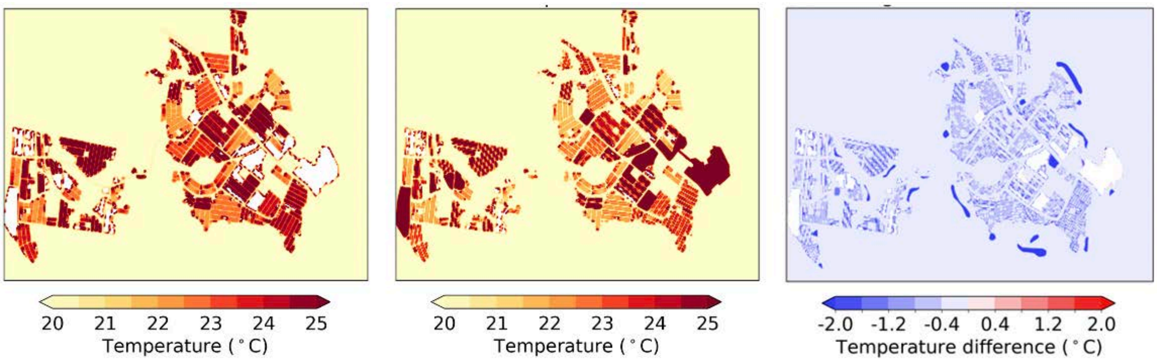

Figure 6. The modelled air temperature for a business as usual residential area on a cool summers day (left), the air temperature when significant amounts of WSUD infrastructure are incorporated into the landscape (centre) and the difference between the scenarios (right).

References

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