Urban Climate News

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From the IAUC President

Welcome to the 53rd edition of the *Urban Climate News*.

I begin my column with some sad news: last week I was informed of the passing of **Dr. Ernesto Jáuregui** (National University of Mexico) on Sept. 18, 2014. Ernesto was a pioneer in the study of climates of tropical cities and made contributions in the areas of urban climatology, atmospheric pollution and human bioclimatology, with a particular emphasis on Mexico City. Ernesto also contributed to WMO and IPCC reports on urban climate and climate change. For these efforts he was recognized by the IAUC with the Luke Howard Award (2005) and by the AMS with the Helmut E. Landsberg award (2012). A fuller tribute to Dr. Jáuregui will appear in the next issue of the *Urban Climate News*.

In late August I was able to attend a few sessions of the World Weather Open Science Conference in Montréal, Canada. The overall conference theme was "Seamless Prediction of the Earth System: from minutes to months" and the intent of the organizers was to bring the entire climate and meteorological community together to review the state of knowledge and to "…act as an international stimulus for the science and its future." Within the wide spectrum of conference topics were a number of urban-themed sessions and presentations by IAUC members. An intended outcome of the conference is a series of White Papers (http://wwosc2014.org/white-papers-e.shtml). IAUC members may be particularly interested in those related to "New Technologies and Observation Instrumentation Innovations: From Urban to Global Scales" and "Numerical Prediction of the Earth system: Putting it all Together."

And on the topic of conferences, a reminder that abstract submissions are now open for ICUC-9 in Toulouse, France (see the conference announcement in this issue). Looking beyond ICUC-9, it is not too soon to start thinking about ICUC-10, which we would anticipate to be held in 2018. Individuals or groups who are interested in organizing ICUC-10 may wish to begin their proposal planning now;

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proposals for ICUC-10 will be assessed by the IAUC Board in Toulouse during ICUC-9. Further information will be circulated later this year – but if any individuals or groups are interested and wish more information now, please feel to contact me.

Finally, as this issue of the *Urban Climate News* goes to press, we are expecting the special issue of ICUC-8 articles to appear very soon in the journal *Urban Climate* (http://www.journals.elsevier.com/urban-climate/).

– James Voogt,
IAUC President

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Mayors at UN climate summit announce pledges toward major carbon cuts in cities

September 2014 — A compact of Mayors from cities around the world announced today that they will expand their commitments to scale up climate resilience efforts, energy efficiency programs and resilient financing mechanisms including through an initiative that aims to reduce their greenhouse gas emissions by 454 megatons by 2020.

According to a statement, these and other initiatives announced at Secretary-General Ban Ki-moon's Climate Summit aim to address the effects of development on the environment both in urban and rural areas.

This particular plan – known as the Compact of Mayors – brings together well over two thousands cities, including over 200 with specific targets and strategies for greenhouse gas reductions. Sixty per cent of the world's population will live in cities by 2030 and that figure increases to 70 per cent by 2050.

"From Rio to Seoul, mayors are already making great progress in fighting climate change and preparing their cities for its devastating impacts," said Rio de Janeiro Mayor Eduardo Paes. "These announcements show the world that we are committed to transparent, easily accessible, emissions reporting."

Other announcements including the City Climate Finance Leadership Alliance and a City Creditworthiness Partnership will also help the world's cities to reduce annual greenhouse gas emissions by 8 gigatons annually in 2050 – the equivalent of 50 per cent of global coal use.

"From Rio to Seoul, mayors are making great progress in fighting climate change and preparing their cities for its devastating impacts... These announcements show the world that we are committed to transparent, easily accessible, emissions reporting."

National Governments can be more ambitious in their emissions reduction commitments, according to research recently unveiled by the UN Secretary General's Special Envoy for Cities and Climate Change and former New York City Mayor Michael Bloomberg.

"Now is the time for nations to partner with cities as they create more ambitious climate targets over the next year, both to help the world avoid the worst impacts of climate change and to benefit millions of people," said Mr. Bloomberg.

Cities, banks, national governments and civil society organizations gathered at the Climate Summit to accelerate commitments to slash greenhouse gas emissions. National Governments, including China, Germany and the United States, also announced their commitments.

Creative City for Design – Shanghai, China. Photo: City of Shanghai. *Source:* UN News Center

The Carbon Cities Climate Registry, the designated central repository of the Compact of Mayors, will serve as a platform for city climate data.

"Today's announcements, including the Compact of Mayors and its standardized reporting process and public data portal, came out of an unprecedented collaboration among city networks," said Seoul, South Korea Mayor Park Won-soon.

About 20 public and private sector partners also united today to launch the City Climate Finance Leadership Alliance to generate trillions of dollars to invest in low-carbon and climate-resistant infrastructure in cities in low- and middle-income countries.

"This will allow increased capital to flow to cities, unblocking the transformational change needed to meet the challenge of climate change and contributing to the new urban agenda of cleaner, more resilient and environmentally sustainable cities," said UN-Habitat Executive Director Dr. Joan Clos.

The World Bank and its partners are uniting to help 300 cities strengthen their creditworthiness to attract investors. This will help cities improve their financial management, which ultimately will boost their access to private capital.

Making cities climate-friendly is one of eight action areas identified as critical during the Abu Dhabi Ascent, a two-day meeting held in the United Arab Emirates in May 2014. Other topics include agriculture and renewable energy. *Source:* http://www.un.org/apps/news/story.asp?NewsID=48800#.VDbKOPmSzDp

Public transport holds key for clean cities, says study

September 2014 — Effective urban transit systems can encourage people out of their cars and provide a cost-effective way to tackle climate change, a report has suggested.

It calculated that emissions from urban transportation could be cut by more than half by 2050 and economies could save in excess of US $100 trillion. The authors added it would also reduce annual premature deaths by 1.4 million.

The report was being published at a UN Habitat III meeting ahead of Ban Ki-Moon's climate summit. The findings were published in a study by researchers from the University of California, Davis, and the Institute for Transportation and Development Policy (ITDP).

Co-author Michael Replogle, ITDP's managing director, said one of the most affordable but often overlooked ways to tackle emissions from human activity was to give people better access to cleaner options of getting from point A to B in urban areas.

"Transportation, driven by rapid growth in car use, has been the fastest growing source of CO_2 in the world," he said. "While every part of the global economy needs to become greener, cleaning up the traffic jams in the world's cities offers the least pain and the most gain."

Providing safer roads for pedestrians and cyclists encourages more people to get out of their cars. *Source:* www.bbc.com

2050 vision

The report offers a vision of how this might be achieved in it's "high shift scenario", in which it envisages a far greater proportion of urban passenger travel via "clean public transport" and non-motorised means, such as cycling and walking.

It also includes a decrease in the rates of road construction, parking garages and other means that the authors consider to encourage car ownership. The report also states that, without changes in policies and investments, rapid urbanisation will result in emissions from urban transportation almost doubling from 2010 levels by 2050.

"The traffic congestion we see today will become much greater and will result in many more hours being stuck in traffic," Mr Replogle said, adding that congestion would also have a detrimental impact on nations' economic activity, as people would be late getting to work or meetings.

"People will have to spend much more on transport that will serve them much less well." He told BBC News that there were signs that policymakers and city planners were embracing a "high shift" vision of the future.

"For example, cities that have reallocated street space to build modern world-class bus rapid transit (systems) have basically got a subway level of service on the surface for a fraction of the cost and a lot better places to walk and cycle, which has changed the way people travel," he explained.

"Now, middle-class people are increasingly taking public transport or using the public bikes instead of taking a car. Lower class people who cannot afford cars have better mobility. Everyone benefits from not being stuck in traffic for hours."

Mr. Replogle said one of the main barriers hampering the transition towards more effective public transit systems was inertia among political leaders and decision makers. "There are literally trillions of US dollars of investment capital waiting for good opportunities to invest in public transport," he suggested. "What's needed is for governments to work with development banks and other institutions to help give a green light to the kind of projects that can reallocate street space to favour public transportation, bicycles and walking. Unlike energy strategies that require investment in more costly technologies, this is a set of investments that simply require investing in better public transportation and making streets safe to walk and bike." — *By Mark Kinver, Environment reporter, BBC News. Source:* http://www.bbc.com/news/science-environment-29207644

Household air pollution puts more than one in three people worldwide at risk of ill health and early death, says study

September 2014 — Household air pollution, caused by the use of plant-based or coal fuel for cooking, heating, and lighting, is putting nearly three billion people worldwide at risk of ill health and early death, according to a new Commission's findings, published in *The Lancet Respiratory Medicine* journal.

A third of the world's population uses plant-based solid fuels such as wood or charcoal, or coal, to cook, heat, and light their homes, primarily in Asia and Africa. These smoky, dirty fuels are often used in an open fire or simple stove, resulting in high levels of household air pollution in poorly ventilated homes.

Studies in India have found that in some areas, household air pollution is so high that it actually increases outdoor (ambient) air pollution – leading to pollution levels more than three times higher than a typical London street, and well above WHO-recommended safety levels.

The Commission, which was led by Professor Stephen Gordon, from the Liverpool School of Tropical Medicine, UK, and Professor William Martin, from Ohio State University, USA, examined evidence for the effects of household air pollution on health. They conclude that an estimated 600-800 million families worldwide are at increased risk of illnesses such as respiratory tract infections, pneumonia, COPD, asthma, and lung cancer.

Estimates suggest that household air pollution killed 3.5 to 4 million people in 2010. Although rates of exposure to household air pollution have been declining slowly in recent years, population growth means that the overall number of people exposed has remained stagnant, at around 2.8 billion people worldwide.

Despite this huge toll of premature death and ill health, coordinated international and country-led efforts to tackle household air pollution have thus far been insufficient, say the authors, and public awareness of the risks of cooking with solid fuels in poorly ventilated homes remains low in the areas most badly affected.

The women and children living in poverty who are most affected by household air pollution are also likely to have poor access to healthcare – especially the complex and expensive treatments required for much of the respiratory illness and cancer caused by household air pollution.

"Although a number of clean cooking technologies – such as advanced cook stoves, LPG or solar power systems – exist, providing affected homes with cleaner ways to cook, heat, and light their homes with biomass fuel will not be the long term solution," says Professor Gordon. "In communities where solid fuel cooking methods are currently the norm, cleaner fuel and cooking methods need to be at least as affordable, efficient, and long-lasting as the traditional style methods they replace. They also need to be fit for the different cultures and regions in which they're used – if families only partially adopt cleaner cooking methods, using them alongside more polluting technologies, we are potentially looking at an expensive failure, and no reduction in the millions of people currently at risk from household air pollution."

Household air pollution caused more than 3.5 million deaths worldwide in 2010, many of young children. *Source:* http://www.humanosphere.org/basics/2013/07/data-show-indoor-air-pollution-a-major-killer-of-kids/

The Commission provides a comprehensive review of the evidence for the effect on ill health and premature death of household air pollution, examines interventions currently available, and promising future developments. It concludes by outlining research priorities which will need to be tackled if this problem is to be effectively reduced.

According to Professor Martin, "All of the evidence we examined in this Commission points to a serious need for improved commitment to tackling the problem of household air pollution. Scientists and health professionals in countries where household air pollution is still widespread need to work with governments and international health agencies to increase awareness of the huge toll that it is exacting on the population. There are many gaps in our knowledge of how to effectively measure and prevent household air pollution, but this problem cannot be solved until the global community recognises the scale of this problem and commits to coordinated and concerted action." *Source:* http://www.sciencedaily.com/releases/2014/09/140902205230.htm

A World Cup in Qatar's heat won't be safe for players – or even spectators

August 2014 — Qatar is currently scheduled to host the FIFA World Cup in the summer of 2022. There are many reasons why this is a terrible idea, but for now, let's just focus on one of them: the heat.

The average summer temperature in Qatar is 106 degrees Fahrenheit. In sweltering heat like that, nobody should be in direct sunlight for very long, let alone playing soccer at a world-class level for ninety minutes. But don't worry, the Qataris have a plan for reducing the pitch temperature to a less frightening 87 degrees in all of their open-roof stadiums: giant fans... lots of them. Good luck with that, wealthy oil tycoons.

The simple fact is that playing soccer outdoors in a Qatari summer isn't safe for players, and, according to a new report in the *International Journal of Biometeorology*,* it might not even be safe for spectators.

Researchers Andreas Matzarakis and Dominik Fröhlich of Albert-Ludwigs University in Freiburg, Germany gathered weather data for Doha – Qatar's capital and the designated home for 6 of the 13 World Cup stadiums – and distilled the collection into a metric called physiological equivalent temperature (PET). PET takes variables like wind, humidity, and solar radiation into account to produce what's essentially an estimated indoor temperature. For example, on an 80-degree day with copious amounts of sunlight and high humidity, the PET might be 95 or higher. Walking around outside would feel like being inside if the temperature were 95 degrees.

When all the numbers were crunched, Matzarakis and Fröhlich actually were forced to update the standard PET table created back in 1996. Here is the original table:

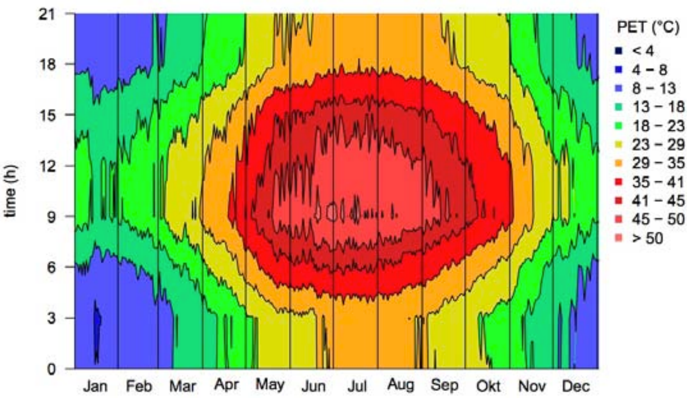
Table 2 Thermal stress classes for human beings (with an internal heat production of 80 W and a heat transfer resistance of the clothing of 0.9 clo (clothing value)).

PET (°C)	Thermal perception	Grade of physical stress
<4	Very cold	Extreme cold stress
4–8	Cold	Strong cold stress
8–13	Cool	Moderate cold stress
13–18	Slightly cool	Slight cold stress
18–23	Comfortable	No thermal stress
23–29	Slightly warm	Slight heat stress
29–35	Warm	Moderate heat stress
35–41	Hot	Strong heat stress
41–45	Very hot	Extreme heat stress

And here are the two levels added in order to fit a Qatari summer:

45–50	Very hot	Extreme heat stress
>50	Very hot	Extreme heat stress

The 2022 FIFA World Cup in Qatar will be outlandishly, mind-bogglingly, barbeque-liciously hot. And that's putting it mildly. Check out this figure showing the calculated PET by time of day for Doha over the course of a year.



You're reading that graph correctly. Between 7 A.M. and 2:30 P.M. during the time of the World Cup, the average PET will be between 45 and 50 degrees Celsius or higher. Converted to Fahrenheit, that's between 113 and 122 degrees! At PETs like that, heat stroke, where the body's temperature rises above 104 degrees Fahrenheit, can occur in a manner of hours or less, Matzarakis says, depending on factors like age, clothing, and alcohol intake. Heat stroke can result in permanent organ damage or even death.

"The results show that this kind of event may be not appropriate for visitors," Matzarakis and Fröhlich simply stated.

Not wanting to ruffle any feathers, they also added:

"It is not the aim of this study to show that Doha City is inappropriate for the FIFA 2022 but to find a time period with the most suitable thermal conditions for visitors and tourists. According to the results, this is the time from November to February."

FIFA is currently considering rescheduling Qatar's World Cup to the winter months to avoid the life-threatening heat, but that may not even be necessary. Qatar's successful World Cup bid is widely thought to be the result of bribery, and a report assessing those allegations is due this fall. If claims of bribery are substantiated, it is highly likely that the 2022 World Cup will be relocated to the second place country, the United States.

— *By Ross Pomeroy at* www.realclearscience.com

* Matzarakis A, Fröhlich D. (2014) Sport events and climate for visitors – the case of FIFA World Cup in Qatar 2022. *Int J Biometeorol*. DOI 10.1007/s00484-014-0886-5

Counterpoint: Cooling open-air sports venues is not science fiction

September 2014 — There is often an element of fantasy linked to the idea of cooling outdoor football stadiums for the 2022 FIFA World Cup in Qatar.

Almost four years on from when I joined the Qatar 2022 Bid Committee and Qatar winning the rights to host the 2022 FIFA World Cup, people still ask me if it is possible to play football here in the summer. My answer is always the same: yes.

I was motivated to work for the Qatar 2022 Bid Committee because Qatar didn't shy away from challenges, they embraced them. As an architect, one always dreams of working on projects that can cause a paradigm shift in the field. After all, Qatar could simply build a retractable roof on a stadium to make things simpler, but then there wouldn't be any need for innovation.

To begin with, Qatar's Al Sadd Stadium, where Real Madrid and Spain legend Raúl González Blanco most recently plied his trade for two seasons, has had fully-functioning outdoor cooling systems working since 2008. Valves around the pitch and below each seat blow cool air into the arena, using traditional power generators. I took CNN International's Becky Anderson to a training session there last fall.

In September 2010, FIFA's technical inspectors attended a Qatar Stars League match at the same stadium between Al Sadd and Al Rayyan – the local derby – when the on-field and spectator tribune temperature was 19 degrees Celsius. And, that wasn't the only cooled venue FIFA visited in Qatar.

In 2010, I oversaw the project to build a prototype, 500-seat version of a proposed FIFA World Cup venue, to showcase specifically to FIFA how the state-of-the-art air cooling systems could be powered using solar energy work. We were able to lower the ambient air temperature to 23 degrees Celsius, when it was in the low 40s outside. FIFA was impressed on both counts.

We want players to have the best conditions for football. I used to live in Miami before coming to the Middle East and I remember watching Mexico play Ireland on television during the 1994 FIFA World Cup in the heat of Orlando (mind you, not uncommon summer weather for many cities across the Northern Hemisphere). Our concept will make sure all teams play comfortably in the same, safe conditions – creating a level playing field.

People then usually ask me: What about the fans?

This summer at a beach in Qatar, we tested our cooling systems in an open-air, custom-built fan zone for the 2014 FIFA World Cup in Brazil. The temperatures inside the fan zone were on average 12 degrees Celsius lower inside the venue.

Our bid was based on the sole intent of hosting the 2022 FIFA World Cup in the summer. We are offering solutions to keep players and fans comfortable – and developing those solutions to ensure that they are environmentally sustainable.

My team of technical and sustainability experts have worked with international climate specialists to analyse the reality of conditions likely to be experienced at the time of the tournament. Every firm who has been appointed to design one of our stadiums has been asked to demonstrate how they plan to cool the pitch to an optimal 26 degrees Celsius and shaded spectator stands to between 24 and 28 degrees Celsius.

This is well below the temperature of 32 degrees Celsius when FIFA requires a cooling break to be taken – as we witnessed at the Estádio Castelão in Fortaleza this summer during the Mexico vs. Netherlands round of 16 match.

Passive and active cooling in outdoor areas will connect stadiums to Qatar's transportation network. As spectators approach a stadium, the average temperature will slowly lower from approximately 32 degrees Celsius, to 26 degrees Celsius (± 2).

We will forge ahead implementing and developing this technology. Our commitment to this is grounded in the legacy it will offer for Qatar and countries with similar climates. It will enable sport to be played 12 months of the year. And, the application of this technology is not limited to stadiums or sport venues. It can be applied in public spaces, so people can enjoy outdoor activities all year round.

We understand the scepticism and respect the work that has gone into the study authored by Professors Andreas Matzarakis and Dominik Froehlich. However, we believe the experts currently developing these groundbreaking technologies will mitigate any concerns for players or spectators visiting Qatar in the summer, where the Qatar Stars League began playing official matches last week.

As with any innovative technology, doubts remain of whether we can deliver, but I believe we are beginning to demonstrate that cooling open-air sport venues is science fact and not science fiction.

— Dario Cadavid is the Technical Assurance & Integration Senior Manager for the Supreme Committee for Delivery & Legacy, the Qatari government entity in charge of leading the country's preparations to host the 2022 FIFA World Cup Qatar. Source: http://www.gulf-times.com/opinion/189/details/410296/cooling-open-air-sport-venues-is-no-science-fiction

Heat waves in urban areas: impacts and mitigation


By Dan Li (danl@princeton.edu)
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Heat waves are amongst the deadliest natural disasters. In this study, observational and modeling analyses are combined to explore the urban heat island effect during a heat wave event over the Baltimore-Washington area, USA. We focus on the potential interactions between the urban heat island effect and the heat wave, namely, whether the urban heat island effect is intensified or weakened by the heat wave. Synergistic interactions between the urban heat island and the heat wave are observed using in-site measurements and high-resolution numerical simulations. That is, not only does the heat wave increase the ambient temperatures, but it also intensifies the difference between urban and rural temperatures. A simplified analytical model is developed and attributes these synergistic interactions to the lack of surface moisture in urban areas and the low wind speed associated with the heat wave. Given that heat waves are likely to become more frequent, stronger and longer in a changing climate, adaptation and mitigation strategies that aim to reduce the heat stresses in urban areas such as the use of green roofs and cool roofs are strongly encouraged. Our results indicate that as the green and cool roof fractions increase, the surface urban heat islands are reduced almost linearly. When green roofs have abundant soil moisture and when cool roofs have an albedo value of 0.7, an addition of 30% green or cool roofs in the Baltimore-Washington metropolitan area can reduce the maximum surface urban heat island by 1ºC. However, it must be stressed that the performances of green roofs and cool roofs are strongly affected by the soil moisture level and the albedo value, respectively.

1. Introduction

Managing the risks associated with extreme events and disasters is becoming more and more important under a changing climate due to their significant socio-economic impacts (IPCC 2012). Heat Waves (HWs) have been demonstrated to be one of the most important global causes of weather-related mortality (Petkova et al. 2014). For example, the 1995 Chicago heat wave caused more than 800 deaths (Changnon et al. 1996). The 2003 European heat wave is estimated to have killed 70,000 people (Robine et al. 2008). HWs typically result from large-scale, stagnant, high-pressure systems that produce a temperature anomaly over a large area; therefore, HWs increase the air temperature and surface temperature for both urban and non-urban areas.

Cities or urban areas are more vulnerable to HWs than rural areas because of the Urban Heat Island (UHI) effect, namely, cities are generally hotter than the surrounding rural areas (Grimmond 2007; Oke 1982). The UHI effect results from many unique characteristics of urban areas such as limited green spaces, radiative trapping effects, higher heat capacity, and anthropogenic heat releases (Oke 1982). The strength of UHI is measured by the so-called UHI index (ΔT), which is defined as the urban and rural air (or surface) temperature difference. As such, even if HWs affect the urban and rural areas in the same way, urban temperatures will be still higher than rural temperatures by ΔT, or the UHI index.

Understanding the genesis and climatology of UHIs is nevertheless not the focus of our study. In this study, the focus is rather on the potential interactions between UHIs and HWs, namely, whether the UHI index (ΔT) will be intensified or weakened by HWs. To answer this question, the UHI effect during a HW event (from June 7 to 10, 2008) in the Baltimore-Washington metropolitan area is studied using a unique combination of approaches, including high-resolution numerical simulations, in-site and satellite observations, as well as an analytical model. For the first time, we are able to demonstrate that UHIs and HWs interact synergistically and non-linearly to produce heat stress conditions in cities that are more adverse than a simple linear addition of the two effects, thus significantly increasing the vulnerability of cities to HWs and climate change. Under such conditions, mitigation strategies aiming to reduce urban heat stresses are critically needed.

2. Hypotheses

There are primarily two heating sources for the atmosphere above cities: the sensible heat from the underlying surface and the heat advected from the surrounding areas. To understand the potential interactions between the two phenomena, we first elucidate how HWs might alter the heating sources for the atmosphere above cities. There are a number of physical attributes of HWs that might cause such alterations:

1. HWs can strengthen secondary circulations that bring cooler air from the surrounding areas and reduce the UHI strength (Hidalgo et al. 2010; Ohashi and Kida 2002). This is particularly important for coastal cities, since the sea surface temperature is lower and steady while the land surface (in this case the urban surface) significantly increases its temperature in response to HWs. As a result, these secondary circulations or sea breeze are significantly intensified and they reduce the UHI effect (Lebassi et al. 2009, 2011).

2. HWs are usually associated with low wind speeds (Ackerman and Knox 2012), which reduce the advective cooling effect (Oke 1982). However, reduced wind speed may also reduce the turbulence intensity and hence the surface-air heat exchange efficiency (coefficient) over cities, which may offset the reduced advective cooling effect for air temperatures but lead to higher surface temperatures.

3. Higher surface temperatures during HWs will shift the energy balance (Equation 1) at the surface in favor of more evapotranspiration (*LE*) and to a lesser extent, ground/stored heat flux (*G*) (Bateni and Entekhabi 2012), following:

$$R_n = H + LE + G \qquad [1]$$

In Equation [1], R_n is the net radiation, H is the sensible heat flux from the surface to the adjacent air, LE is the latent heat flux into the atmosphere from evapotranspiration, and G is the heat flux into the underlying solid surface (ground and buildings). All variables are in units of W m^{-2}. Note that this surface energy balance equation is written for an infinitesimally thin layer at the air-surface interface rather than for the whole urban layer. The shift of the surface energy budget towards more evapotranspiration is expected to be more prominent in rural areas with higher availability of surface moisture, and this unequal shift in the surface energy budget will increase the UHI effect.

In short, the first and second hypotheses are linked to wind speed effects, while the third is connected to the urban-rural contrast in terms of surface moisture availability. The first hypothesis results in negative interactions between UHIs and HWs, while the second and third hypotheses lead to synergistic interactions between UHIs and HWs.

3. Methodology

In this study, the Weather Research and Forecasting (WRF) model (Skamarock and Klemp 2008) is used to perform high-resolution simulations over the Baltimore-Washington metropolitan area in the United States using three nested domains with horizontal grid spacings of 9km, 3km and 1km. As shown in Figure 1, the largest domain (d01) covers most of the northeastern US; d02 includes Delaware, most of Maryland and parts of West Virginia and Virginia; d03 covers the Baltimore metropolitan area and the Washington, DC, metropolitan area. The three domains have 100, 121 and 121 horizontal grid cells, respectively, in both the x and y directions. In the vertical direction, 109 grid cells are used in order to resolve the boundary layer structure. All the analyses are conducted using simulated results from d03. Other model configurations are provided in Li and Bou-Zeid (2013). We should also point out that a variety of sensitivity tests have been carried out, which demonstrate that the simulated UHI effect is very sensitive to the Planetary Boundary Layer (PBL) schemes during the nighttime and to the thermal roughness length parameterizations during the daytime (Li and Bou-Zeid 2014), but we will not elaborate on these results here. The simulated UHI effect is also strongly affected by the urban parameterizations, or the Urban Canopy Models (UCMs, see Li and Bou-Zeid 2014 for further details and validation).

Due to the importance of UCMs (Grimmond et al. 2010; Grimmond et al. 2011; Li and Bou-Zeid 2014; Zhang et al. 2011), an improved Urban Canopy Model (hereafter the Princeton Urban Canopy Model, or

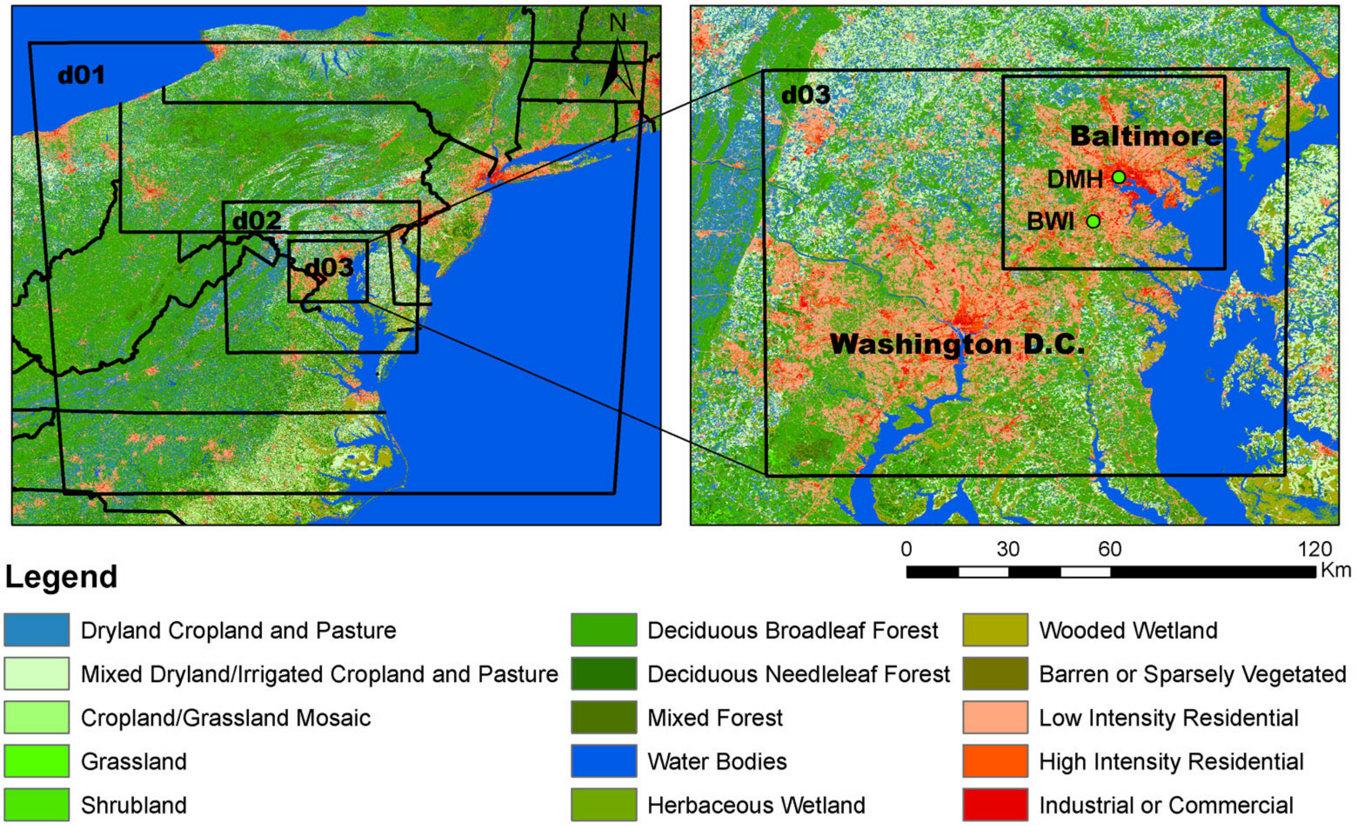

Figure 1. The land-cover map, the WRF domains, and the observational sites over the study area. The black square centered over Baltimore city is the area within which spatially-averaged urban and rural air/surface temperatures are computed based on the underlying land-use category (water surface excluded). Reproduced from Li and Bou-Zeid (2013).

PUCM) is implemented into WRF to parameterize urban surface and hydrological processes. The new capabilities of PUCM include simulations of subfacets with different surface properties (which is also a key to study UHI mitigation strategies as shall be seen later), the better representation of hydrological processes in urban areas and the use of calibrate surface properties for urban areas in the Northeastern US. The full details of the PUCM and the material properties can be found in Wang et al. (2011a, b; 2013), with further offline validations in Ramamurthy and Bou-Zeid (2014) and Ramamurthy et al. (2014). A detailed evaluation of PUCM coupled to WRF and comparison between the PUCM and the default UCM in WRF is presented in Li and Bou-Zeid (2014). In short, as compared to the default option, the PUCM captures the surface UHI effect more accurately, and reproduces more realistic boundary layer temperature profiles.

In order to provide a comprehensive understanding of the interactions between UHIs and HWs, both 2-m air temperature and surface temperature are used to define an UHI index, which are called 2-m atmospheric UHI and surface UHI, respectively. To compute a spatially representative UHI index, the WRF-simulated urban and rural temperatures are first spatially averaged over the Baltimore City metropolitan area (part of d03, see Figure 1) and then the difference between the spatially averaged urban and rural temperatures is calculated.

4. Results

Observational and Numerical Analyses

Before examining the WRF-PUCM simulated UHIs, the UHI effect inferred from 2-m air temperature measurements at two observational sites, DMH in downtown Baltimore and BWI in the suburbs of Baltimore (the locations of the two observational sites are shown in Figure 1), was analyzed (not shown here). It was found that the daytime UHI index is enhanced significantly compared to the periods before and after the HW, implying synergistic interactions between the UHI and the HW. The nighttime UHI index is also intensified compared to the period before the HW, but the maximum of the nighttime UHI index occurs in the post-HW period. This is due

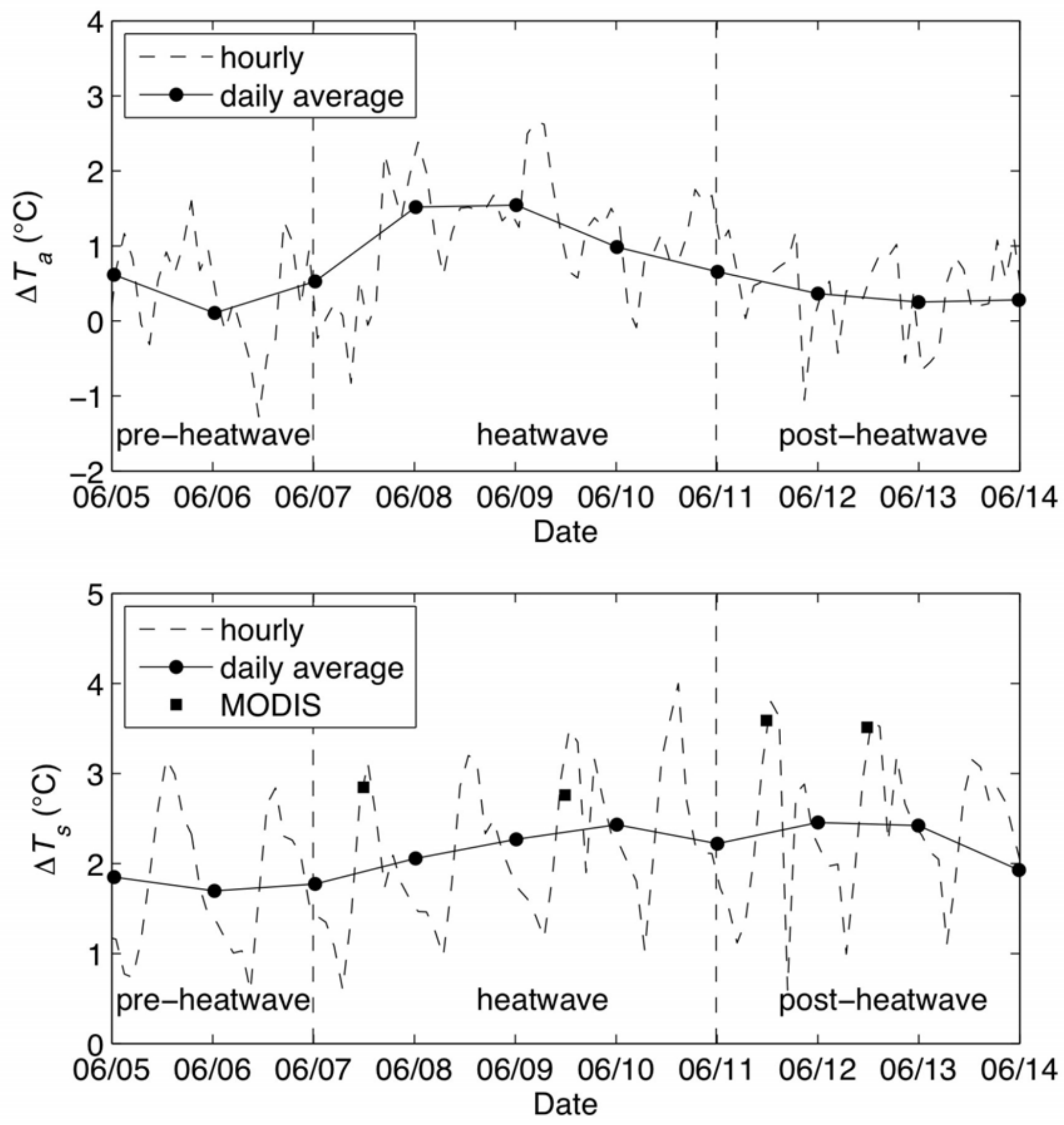

Figure 2. Top panel: 2-m air temperature differences (ΔTa) between the urban and rural areas around Baltimore city simulated by WRF. Bottom panel: surface temperature differences (ΔTs) between the urban and rural areas around Baltimore city simulated by WRF and measured by MODIS. Adapted from Li and Bou-Zeid (2013).

to the larger heat storage in urban areas than in rural areas during the HW period, which is subsequently released during nighttime (Fischer et al. 2012; Oke 1982; Oleson et al. 2011). This is consistent with the fact that the nighttime UHI effect is more prominent than the daytime counterpart, as demonstrated by many previous observational (Oke 1982) and modeling studies (Fischer et al. 2012; Oleson et al. 2011).

The in-site measurements are only taken from two single points and therefore they might be strongly modulated by local effects such as topography and land-sea contrast. To conduct a more spatially representative comparison, WRF-PUCM simulated UHIs are used. The spatially averaged 2-m atmospheric UHI (top panel) and surface UHI (bottom panel) are shown in Figure 2. It is evident that the 2-m atmospheric UHI effect is intensified during the HW period compared to the preceding and following periods. The surface UHI effect is slightly different from the 2-m atmospheric UHI effect. The surface UHI is fairly constant in the pre-HW period and starts to increase as the HW sets in. It reaches its maximum shortly after the event rather than during the HW period. So despite that both urban and rural surface temperatures drop, their difference increases shortly after the HW event. This phase lag in the peak surface UHI index is again a signature of the larger heat storage in the urban areas than in the rural areas (see Li and Bou-Zeid 2013 for analysis of the heat storage difference between urban and rural areas), which is a serious adverse effect since it extends the hot conditions in cities. As a result, the WRF-PUCM simulated results are in good qualitative agreement with the single-point in-site observations, despite the significant differences in their characteristic spatial scales. It must be also pointed out here that the increase in the simulated surface UHI index is in good agreement with the UHI measured by MODIS satellite, which is consistent with our validation results (see Li and Bou-Zeid 2013).

A Simplified Analytical Model

The observational and WRF results suggest that there exist synergistic interactions between the UHI and HW effects for this Baltimore HW event. However, it is unclear whether these findings are unique to Baltimore and to this HW event, or are more general. In addition, it remains unclear what are the physical processes that are driving this synergistic interaction? To address these two questions, we develop a simple analytical model, which includes the main physical processes contributing to the synergistic interactions observed and simulated between UHIs and HWs, namely: wind speed effects, soil moisture effects, albedo and other radiative effects. The analytical model solves heat and water vapor exchanges between the urban surface and the atmosphere in a two-dimensional domain by coupling the surface energy balance equation (Equation 1) with simplified advection-diffusion equations for heat and water vapor in the atmosphere. For the full details and derivations of the analytical model, the readers are referred to Li and Bou-Zeid (2013). Here only a few important conclusions from the analytical model results are presented.

Through this analytical model, we find that the UHI effect is primarily induced by urban-rural contrasts of available water (which can be represented by the soil water content) and available energy ($H + LE$ in equation 1) at the surface. However, the UHI strength is significantly more sensitive to the contrast of available water at the surface and hence is increased during HWs since the rural areas, which have more available water in general, tend to evaporate more and reduce their temperatures during HWs but the urban areas do not have the same capacity or mechanism. As a result, the synergistic interactions between UHIs and HWs are primarily attributed to the contrast in available water between the cities and their rural surroundings.

The UHI is also affected by the wind speed and the contrast of available energy. As mentioned in the introduction, there are both positive feedbacks and negative feedbacks associated with decreased wind speed during HWs. During the daytime, decreasing the wind speed mainly reduces the heating rate in urban areas and hence reduces the UHI; during the nighttime, decreasing the wind speed primarily reduces the advective cooling and thus increases the UHI. The available energy is usually positive during the nighttime and negative during the daytime, which explains why the UHI effect is typically more prominent during the nighttime. However, its variation is not strongly affected by the presence of HWs.

Guided by the results from the analytical model, we proceed to investigate (1) how increasing the water availability in urban areas can reduce the UHIs and their interactions with HWs, and (2) whether reflective roofs with high albedo in urban areas can also reduce the UHIs by reducing the available energy.

Impacts of Green Roof and Cool Roof Strategies

In this section, the city-scale cooling effects of green roof and white roof strategies are examined using the same WRF-PUCM modeling system. This is thanks to the new capability of PUCM, as compared to the single-layer UCM in WRF, in simulating subfacets consisting of different materials (e.g., roof surface can be a combination of conventional roof, cool roof and green roof). The details about the simulations and results can be found in Li et al. (2014). Here, only the impacts of green roof and cool roof mitigation strategies on the surface UHI effects when these roofs are under 'default' conditions, namely, the green roofs have abundant soil moisture (0.3 m^3 m^{-3}) for evapotranspiration and the cool roofs have an albedo value of 0.7, are shown in Figure 3.

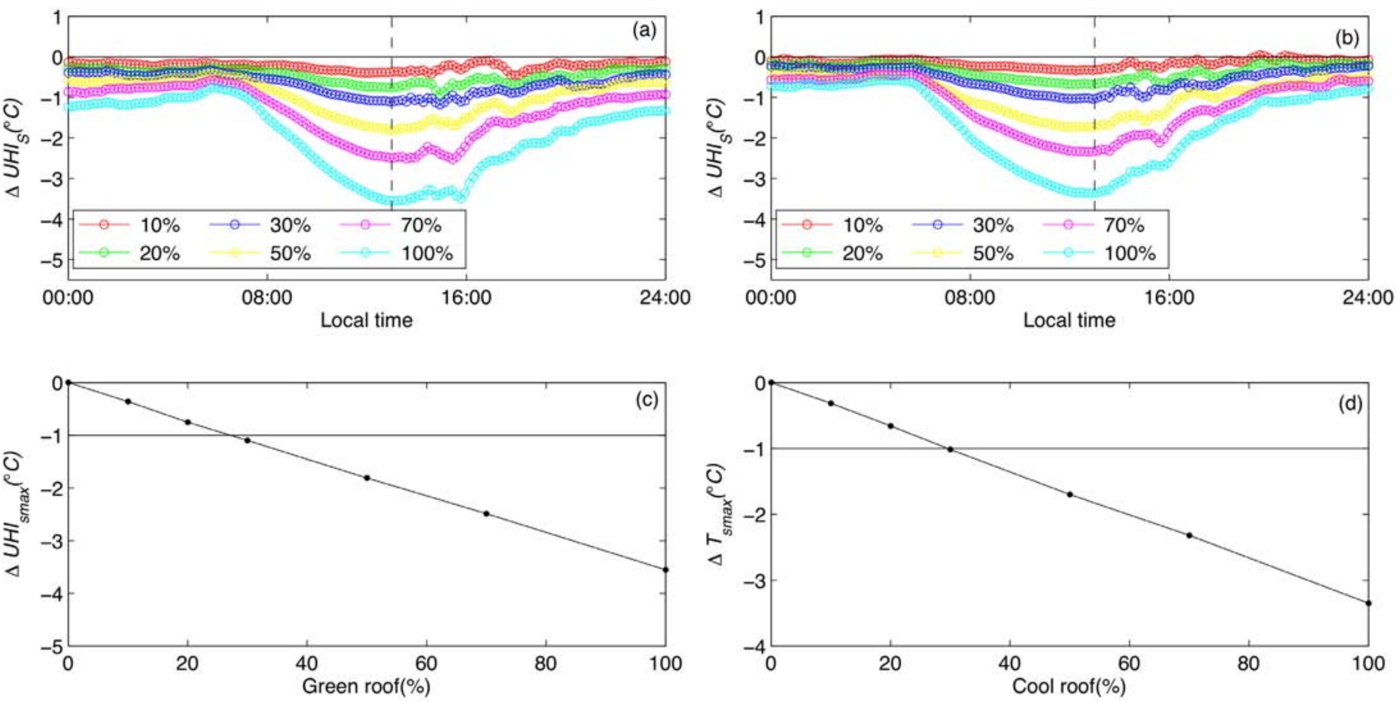

Figure 3. The city-scale averaged reductions in the surface UHIs due to increasing coverage fractions of green roofs (left) and cool roofs (right). (a) and (b) are averaged diurnal cycles of reductions in the surface UHIs during the HW period; (c) and (d) are the maximum reductions in the surface UHIs, whose occurrences are indicated by the black dashed lines in (a, b). Adapted from Li et al (2014).

As can be seen from Figure 3(a), increasing green roof fractions can strongly reduce the daytime surface UHI, but only moderately reduces the nighttime surface UHI. This is because increasing green roof fractions significantly increases the daytime evapotranspiration but has little impact on the nighttime evapotranspiration due to the energy limitation for nighttime evapotranspiration. However, it can be seen that the green roof strategy, despite its little impact on evapotranspiration during nighttime, still has certain influence on the nighttime UHI, suggesting that the cooling effect during daytime can last throughout the night due to reduced heat storage in the urban canopy. The cool roof strategy has broadly similar impacts in terms of reducing the surface UHI (c.f. Figure 3b and 3a). For example, it has a stronger impact on the daytime surface UHI but a rather lower impact on the nighttime surface UHIs, which is related to the absence of incoming solar radiation during nighttime. Similarly, the cool roof strategy still maintains some influence on the nighttime surface UHI despite the absence of incoming solar radiation, which is again due to the reduced daytime heat storage. Figure 3(c) and 3(d) suggest that the reductions in the surface UHI at the time when the surface temperatures reach their maxima (indicated by the black dashed lines in Figure 3a and 3b), which are also the maximum reductions, scale about linearly with the green/cool roof fractions. To reduce the maximum surface UHI by 1°C, the Baltimore-Washington metropolitan area needs to have about 30% of its roofs converted to green or cool roofs. Results not shown here suggest that the impact on air temperature is lower, as expected.

It needs to be emphasized that the performance of green roofs described here is closely linked to the soil moisture conditions (Sun et al. 2013). When the soil moisture conditions are altered, the performance of green roofs will change accordingly (see Li et al. 2014). Similarly, the performance of cool roofs discussed here is specific for cool roofs with an albedo of 0.7. When the albedo of a cool roof is changed due to dirt accumulation for example, its performance will also be modified, as shown in Li et al. (2014). Our results here indicate that cool roofs with an albedo value of 0.7 (a high value representing newly installed or cleaned cool roofs, see e.g., Gaffin et al. 2012) have comparable effects on the surface UHIs to green roofs with a relatively high soil moisture value. This is consistent with Gaffin et al. (2005, 2010) who show that the albedo required on a non-green roof to reproduce the surface temperature observed on a green roof is in the range of 0.7 to 0.85.

5. Conclusions

In this study, the UHI effect throughout a HW event (June 7 to 10, 2008) over the Baltimore area is investigated using a combination of observational, numerical and analytical analyses, with a specific focus on the interactions between the UHI and the HW effects. The most striking finding of this study is that, not only does the HW increase the absolute magnitudes of urban and rural temperatures, more importantly it synergistically interacts with the UHI effect to intensify the difference between the urban and rural temperatures and thus result in higher heat-related impacts in cities than a linear combination of UHI and HW effects.

A simplified analytical model is then developed to unravel the physical mechanisms that are responsible for the interactions between UHIs and HWs. The results indicate that the shift of the surface energy balance towards higher evaporation is an important mechanism to reduce the rural temperatures during HWs, which is however hindered in urban areas by the lack of vegetation and surface moisture. This largely explains the increases in UHI indices during HWs. Other factors such as the decreasing wind speed during HWs also contribute to the synergistic interactions.

Considering the rural area as a reference, urban populations are already living in a hotter environment due to the UHI effect. The synergistic interactions between HWs and UHIs exacerbate the hostile micrometeorological conditions in cities. Unfortunately, HWs are very likely to become more frequent, stronger and longer in a warming climate (IPCC 2012). As a result, urban residents (especially the vulnerable groups such as the elderly and those who have no access to air conditioning) will be at a greater risk of heat-related mortality and morbidity as compared to their rural counterparts. Consequently, adaptation and mitigation strategies, such as the use of green and cool roofs, are strongly needed and encouraged. Our results indicate that as the green and cool roof fractions increase, the surface (and near-surface, not shown here) UHIs at the time when the surface (and near-surface) temperatures reach their maxima are reduced almost linearly. To reduce the maximum surface UHI by 1°C, the Baltimore-Washington metropolitan area needs about 30% of the roof areas to be covered by green roofs that have abundant soil moisture (~ 0.3 m^3 m^{-3}), or by cool roofs that have an albedo value of 0.7. However, it is again stressed that the performances of green roofs and cool roofs are strongly affected by soil moisture and albedo, respectively. Irrigation and constant washing might be needed to maintain the performances of green roofs and cool roofs, respectively, which can be economically viable in certain regions (see e.g., Sun et al. 2014 on the cost-benefit analysis of irrigation over green roofs in summer in Beijing, China).

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Influences of street tree diversity on microclimate, human thermal comfort and heat wave resilience in Melbourne, Australia

Introduction

Trees in urban areas are diverse in many ways, including the species planted, their age, health and architectural form, and their canopy density and leaf characteristics. The diversity of urban trees also varies according to the management and challenging environmental growth factors. All of this urban tree diversity also contributes to differences in urban microclimatic benefits at the micro-scale; i.e. the street scale and smaller. Many recent studies have highlighted the importance of urban trees for their modification of local microclimate, a key benefit to the local urban residents and street pedestrians (Shashua-Bar et al., 2009, Georgi and Zafiriadis, 2006). Changes in microclimate can greatly benefit pedestrians in the urban landscape by improving human thermal comfort (Shashua-Bar et al., 2011). What is required now is an understanding of how microclimate benefits differ for different urban tree species or functional types, as well as how much these benefits can vary within a single species depending upon changes in canopy characteristics; primarily density, because of differences in management, growth conditions or tree health. Part of my PhD research studies focus upon this very issue, by studying the mid-day microclimate benefits of three common, yet contrasting, urban tree species: *Platanus x acerifolia* (London Plane); *Ulmus procera* (European Elm) and *Eucalyptus camaldulensis* (River gum). For each tree species there is a great range of canopy densities, which provides an opportunity to investigate this canopy quality research question from a within-species perspective, as well as to some degree, from an inter-species cross-comparison perspective.

At the same time, a high diversity of species in the urban forest can be regarded as a feature of resilience – having a greater diversity of tree types means there is inherently a greater resistance to the spread of pests and pathogens as well as to the deleterious effects of drought and heat waves. Increasing the diversity of our street tree populations is a clear climate change adaptation mechanism (City of Melbourne, 2012). However, as an urban forest is continually in a state of replacement and renewal, it would be extremely beneficial to know which tree species may gradually become unsuitable because of their vulnerability to the predicted increase in the frequency and intensity of drought and prolonged high temperatures (i.e. heat waves). Vulnerable tree species may respond with a partial or complete loss of leaves, and eventually mortality through dehydration or secondary disease (McDonnell, 2012). Again, from a microclimate perspective the partial or complete loss of tree canopy is an important issue, as it will influence the microclimatic and human thermal comfort benefits provided at a time when they are most crucial (VCCCAR, 2012). Similarly, this has been a focus of my PhD research, to track the performance of these three common urban trees (Plane, Elm and Eucalypt) through a challenging summer of extreme heat events. Melbourne has a Temperate-Mediterranean like climate with warm to hot summers and occasional extreme heat events. Fortunately for me (though not for the residents, or the tennis players in the Australian Open!) there was a serious, record-breaking heat wave in late January 2014 that provided the opportunity to do just this.


Figure 1: Portable weather station used for microclimate measurements.

Methods applied

All measurements were conducted in Melbourne, Australia in one- to two-storey residential streets with pedestrian pavements. Microclimate measurements of wind speed, air temperature, relative humidity, solar radiation and mean radiant temperature (T_{mrt}) were all measured using mobile and fixed climate stations. Mobile climate stations (1.0 m height) enabled six pavement locations to be repeatedly measured (every 2 hours) on two streets on the same day, under the same climatic conditions. Similarly, these mobile climate stations enabled a range of canopy qualities to be measured for a given species under the same mid-day climate conditions. Fixed climate stations (1.0 m height) enabled continuous and full 24-hour microclimate data to be measured, but for fewer pavement locations for three days during summer by using weather stations (Figure 1).

These microclimate variables were used to indicate human thermal comfort by estimating the Physiological Equivalent Temperature (PET) using RayMan software (Matzakaris et al., 2007). All the measured microclimate parameters were used as input for this estimation of pedestrian thermal comfort as expressed by PET.

Case study examples

Different Canopy Qualities and Pedestrian Thermal Comfort

Given that higher canopy cover, or better canopy quality, should provide better microclimate benefits, we investigated how different canopy qualities for three different street tree species influenced the mid-day microclimate underneath. The three tree species were *Platanus x acerifolia*, *Ulmus procera* and *Eucalyptus camaldulensis*. For each species, a range of trees (n=9) with different canopy qualities was selected for measurement. Canopy quality was measured through cover photography (MacFarlene et al. 2007) to estimate a Plant Canopy Index (PCI) that includes an area estimate of both leaves and branches (Figures 2 and 3).

Control measurements were made in the open, away from tree canopies or building shade and were allocated a zero PCI value. PCI for *Platanus x acerifolia* ranged from 0.641 to 5.079, *Ulmus procera* from 2.132 to 6.141 and *Eucalyptus camaldulensis* from 1.308 to 2.747. *Eucalyptus camaldulensis* had a smaller PCI range because of the inherent clumped canopy, thin open canopy and pendulous leaf characteristics. In contrast, *Platanus x acerifolia* is a large broadleaf tree with rounded to pyramidal canopy and *Ulmus procera* a small broadleaf tree with a dense and rounded canopy.

Solar radiation below the canopy for all three species was significantly reduced as PCI increased. However, at PCI values > 4 for *Platanus x acerifolia* and *Ulmus procera*, any further decrease in solar radiation transmittance was relatively small (Figure 4). The advantage of having greater solar radiation interception by a tree canopy is that it provides greater pedestrian shading and cooler ground surface temperatures (Brown and Gillespie, 2005), both of which drive the reduction in T_{mrt} and therefore improve pedestrian thermal comfort (Shashua-Bar et al., 2011). Furthermore, T_{mrt} significantly correlates with PET (Figure 5), indicating that it strongly dictates pedestrian thermal comfort (Matzakaris et al., 1999).

PET decreased as PCI increased for all three tree species. For *Platanus x acerifolia* the difference in PET between PCI 5.1 and PCI 0.64 equated to 7.2°C, taking the human thermal experience from 'slightly warm' to 'very hot'. For *Eucalyptus camaldulensis*, which provided a smaller range of PCI conditions due to its canopy architecture and leaf characteristics, PET indicates that below- canopy conditions remained 'very hot' for pedestri-

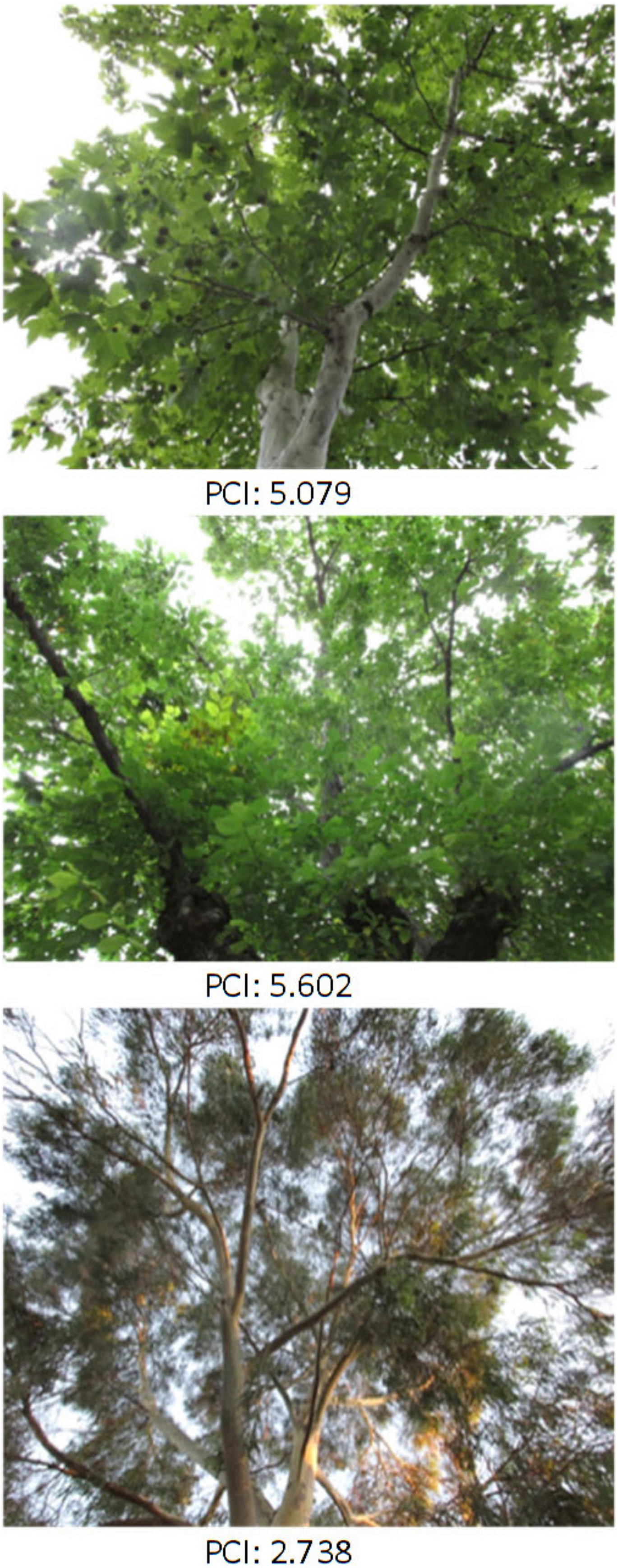

Figure 2: Three street tree species of *Platanus x acerifolia* (Top), *Ulmus Procera* (Middle) and *Eucalyptus camaldulensis* (Bottom) with varying canopy quality measured as Plant Canopy Index (PCI). PCI value of 0 is for open space as control.

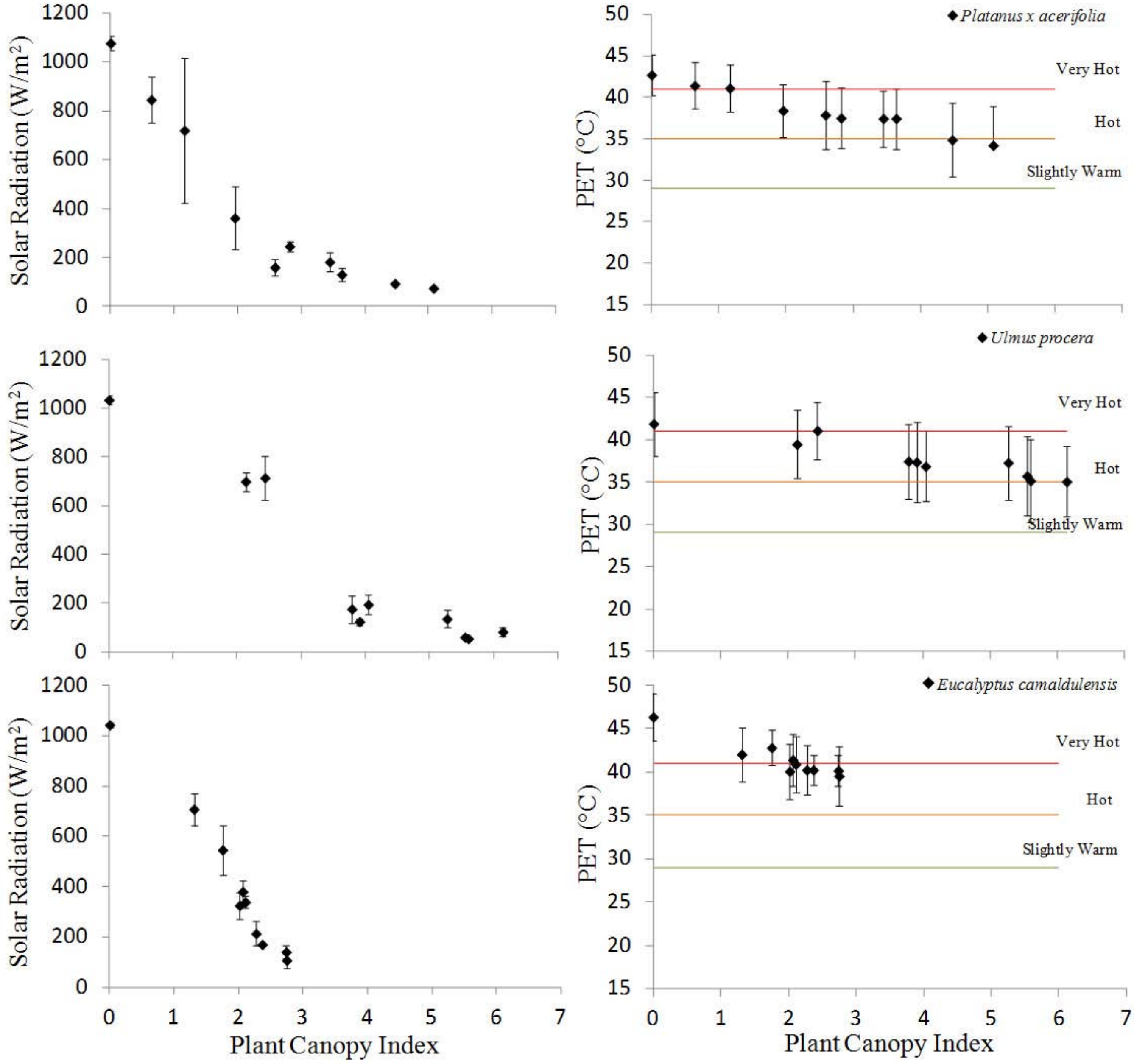

Figure 3: Plant Canopy Index (PCI) vs. average solar radiation and Physiological Equivalent Temperature (PET) for three street tree species. These results are the average of three-day measurements during summer 2014 in Melbourne, Australia.

ans. As solar radiation increased, the concurrent increase in PET below the canopies of all three tree species was the same, as indicated by the similar slope in Figure 4. However, at any given 'above-canopy' solar radiation load, the PET value beneath a *Eucalyptus camaldulensis* canopy will be ~3°C greater than the other two species (Figure 4), whereas despite the differences between *Platanus* and *Ulmus,* their thermal benefits are comparable for a given solar radiation load.

Changing Canopy Quality in Response to a Heat Wave

In this study, we measured microclimate conditions below *Platanus x acerifolia* tree canopies from sunrise to sunset throughout the summer of 2012/13, which included measurements before and after a record heat wave event with four consecutive days with daytime maxima over 40°C (Bureau of Meteorology, 2014). Although *Platanus x acerifolia* is a very popular urban tree species throughout temperate Europe, North America and Australia, it is clearly vulnerable to heat wave events as this species shed most of its leaves, reducing PCI from 4.56 to 1.99 (Figure 5). From a microclimate perspective, solar radiation interception by the *Platanus x acerifolia* canopy before the heat wave was high, greatly reducing T_{mrt} and PET. However, after the heat wave, microclimate conditions beneath *Platanus x acerifolia* were little different from those in the open street without trees. On two similar climate days (Figure 5), one before and one after the heat wave, PET increased from 27.3°C to 31.5°C, which would suggest an approximate 4.0°C loss of human thermal benefit from these urban trees. Consequently, this tree species should be planted more cautiously and in full consideration of the likely increase in extreme urban climate conditions in coming decades. *Platanus x acerifolia* may not be able to sustain ecosystem service benefits that it has become valued and renowned for in cities throughout the world, because once the leaves drop after a heat wave, the thermal comfort benefits (as well as rainfall interception, pollution interception, and aesthetic value) are greatly reduced for the rest of that summer season.

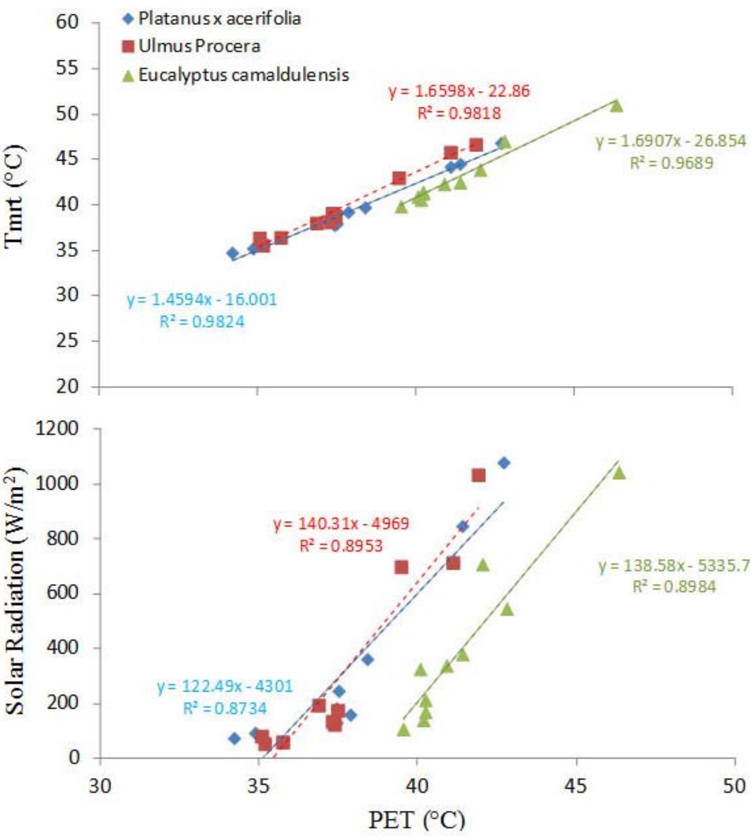

Figure 4: Relationship between mean radiant temperature (T_{mrt} - top) and solar radiation (bottom), and Physiological Equivalent Temperature (PET) for three street tree species. The result is the mean of all three days of measurement during summer 2014 in Melbourne.

Conclusions

This research was designed to look at how street trees can alter street microclimate and influence pedestrian thermal comfort by investigating indices such as PET. It was clearly found that streets with high-quality canopy cover had cooler microclimate conditions in summer. A heat wave can affect canopy quality in some tree species through leaf loss, as demonstrated for the globally popular urban tree *Platanus x acerifolia*.

Through these studies, it is important to note that solar radiation interception by the tree canopy plays a significant role in urban areas as it provides shading benefits, relatively cooling the surfaces below the canopy and improving PET. Given that a reduction of heat load at street level is important for pedestrian thermal comfort, selection of tree species that can provide better canopy quality, or managing existing trees for better canopy quality, is important during hot and dry summers like those that Melbourne frequently experiences. These findings can inform urban planners and managers on species selection and canopy management for our future urban forest.

Acknowledgement

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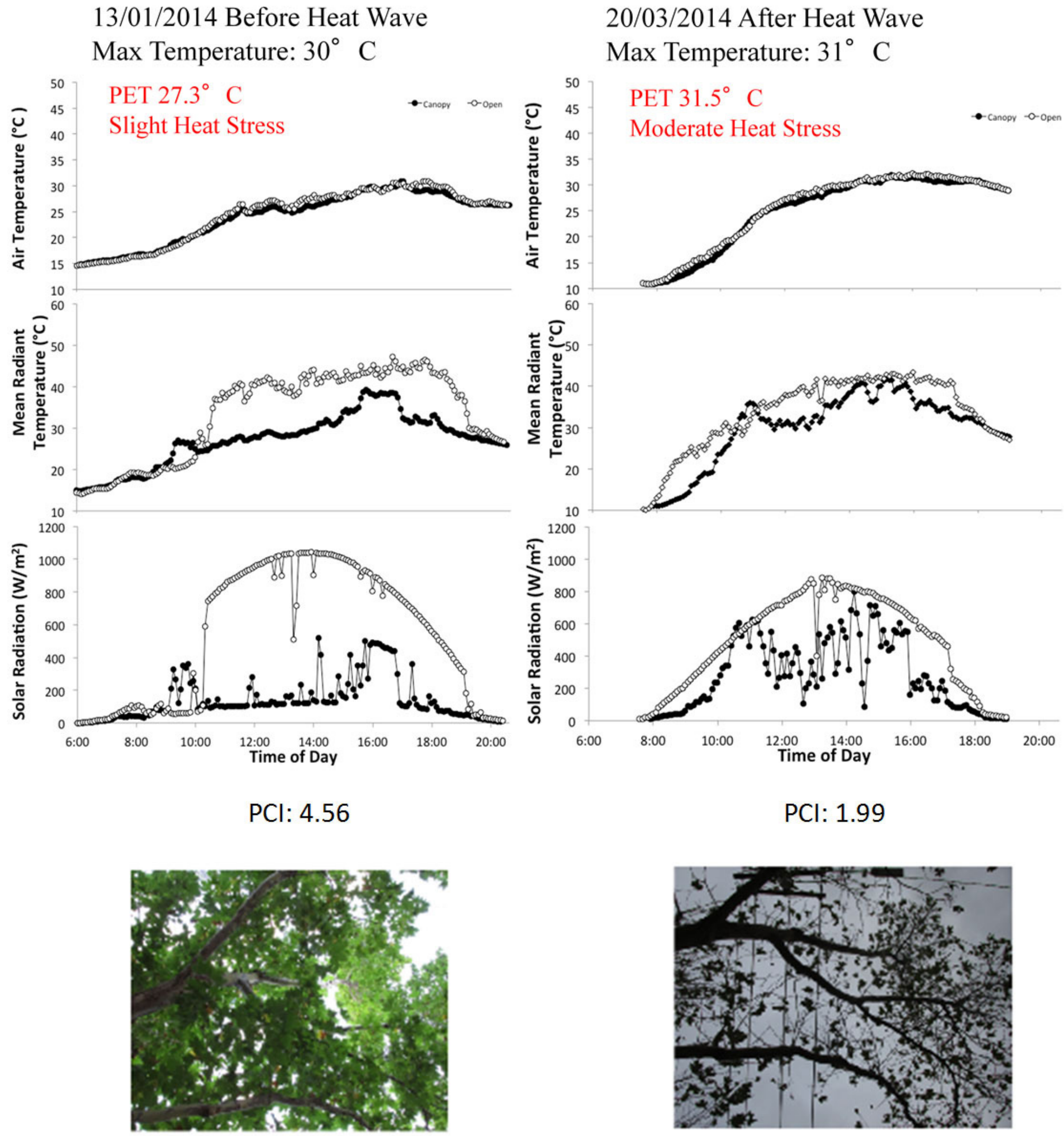

Figure 5: Above: Below-canopy microclimate of air temperature, mean radian temperature (T_{mrt}) and solar radiation for *Platanus x acerifolia* species before and after heat wave in Melbourne. Below: Example of *Platanus x acerifolia* canopy and Plant Canopy Index (PCI) before and after heat wave.

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In An Urban Atmosphere

Climate-related issues raised at IGU Regional Conference in ***Kraków, Poland***

By David Pearlmutter, Editor

A full program of sessions devoted to the climate of built-up areas was held on August 19th and 20th at the International Geographical Union's 2014 Regional Conference in Kraków, Poland. These sessions were organized and co-chaired by **Hadas Saaroni** of Tel Aviv University in Israel, and **Krzysztof Fortuniak** from the University of Łódź, Poland.

The lectures and posters presented over the course of two days addressed a broad spectrum of issues relating to both the physical and human aspects of urban climate, at a range of spatial and temporal scales:

- *Urban Heat Island (UHI) effects* – long term intensification trends and case studies from selected cities
- *Links between synoptic and city weather* – UHI intensity under varying synoptic systems and wind regimes
- *Climatic design* – from building-scale to urban-scale, including open-space planning with an emphasis on thermal comfort and perception in urban parks
- *Environmental challenges* – radon, air pollution, influences of changing energy consumption
- *Methodological innovations* – techniques for characterization of urban surface properties

In the first of four sessions with oral presentations, a number of case studies were presented from locations in and around the organizers' host countries. **Oded Potchter** presented his work with **Limor Shashua-Bar** on using urban greenery for cooling in different climatic zones of Israel, and this was followed by an analysis of microclimate and thermal perception (**Saaroni**, **Pearlmutter** and **Hatuka**) in a newly-constructed park along the Mediterranean coast in the city of Tel Aviv-Jaffa. Predictions of future warming trends in Israeli cities were offered by **Hofit Itzhak Ben-Shalom**, based on a modeling study together with several of her co-investigators. Moving to Eastern Europe, **Márton Kiss** gave assessments made with colleagues in Hungary of urban ecosystem services in Szeged, and **Krzysztof Blazejczyk** spoke about the UHI dynamics in Warsaw based on his case studies with Polish colleagues on selected housing estates.

Opening the second session was **Nigel Tapper** from Melbourne, who gave a panoramic view of his group's multi-faceted work on mitigating heat-related health risks in Australian cities, through technology and water-sensitive urban design. A particular aspect of this latter theme, involving climate-conscious rainwater management, was addressed by **Ágnes Gulyás** and colleagues from Szeged. **Takehiko Mikami** and his Japanese team examined the after-effects of the Fukishima nuclear crisis in 2011, producing evidence that reduced electricity consumption in the wake of the disaster may have in turn reduced the UHI intensity in Tokyo. Finally, some of the geographical aspects of emissions from heating systems were discussed by **Martin Jurek**, who carried out a municipal-level case study in the Moravia region of the Czech Republic.

The final session of the day was kicked off by the venerable **Annick Douguedroit**, who together with **Sébastien Bridier** surveyed trends in the nocturnal UHI of Mediterranean cities over the course of 60 years, and a similarly long-term climatic portrait was presented for the city Łódź (**Fortuniak** and colleagues). The Local Climate Zones classification of Stewart and Oke was the focus of two case studies in Central European cities, one by **Jan Geletič** and **Michal Lehnert**, and the other by **Stevan Savic** and colleagues. An eye-opening case study from the city of Turku in southwestern Finland was served up by **Juuso Suomi**, who in describing the spatiotemporal characteristics of the local heat island during different weather patterns, reported urban-rural temperature differences of up 10°C – with the higher reading in the city registering at 18.5°C... below zero!

On the following day, one last session was held – starting with a presentation by **Tamas Gal** on a new method for calculating the roughness length parameters that govern turbulent air flow over cities. **Włodzimierz Pawlak** and colleagues also looked at turbulent exchanges, in this case of methane in urban areas and above wetlands. Radon in the urban atmosphere was the topic of discussion for **Agnieszka Podstawczyńska**, also from Łódź, and the session was closed out by **Wolfgang Sulzer**, who together with **Reinhold Lazar** looked at the last 40 years of urban climate analysis for planning purposes in Graz, Austria.

Beyond these oral sessions on urban climate – and a related poster session with some 15 presentations – a total of 12 oral and poster sessions on other climatic topics were organized at the conference by the IGU's Commission on Climatology (CoC). These topics included:

- Historical climatology (3 sessions)
- Climate change and variability, and their environmental impacts (3 sessions)
- Weather and climate extremes (2 sessions)
- Climate change and variability at different spatial and temporal scales
- Climate modeling / GIS and remote sensing methods in atmospheric sciences
- Atmospheric circulation at different scales
- Polar and mountain climates

In this framework, plenary lectures were given by **Julie Winkler** from Michigan State University on "Embracing the Complexity and Uncertainty of Climate Change: Responsibilities for Geographers," and by **Zbigniew W. Kundzewicz** of the Polish Academy of Sciences on "Climate change, related challenges and responsibilities."

The full program of the IGU Conference in Kraków – whose theme was *Changes, Challenges, Responsibility*, and which attracted 1400 participants representing 65 countries on all continents – can be found online at http://www.igu2014.org/downloads/igu2014_programme.pdf.

Two centuries of urban meteorology

...in the heart of Florence, Italy

Located in the historic center of the city of Firenze, the **Ximeniano Observatory** was founded in 1756 for astronomical studies – and has recorded meteorological data continuously from 1813 to the present. This 200-year record, indicative of climatic changes in a densely urbanized zone in central Italy, has become a focus of interest for urban climatologists. Last year, to commemorate this milestone, a conference was held in Florence to stimulate discussion on urban climate and the history of meteorology (www.bo.ibimet.cnr.it/repository/proceedings).

More recently I had the privilege of taking a guided tour of the observatory's strikingly rich collection of instruments, which have been used there over the course of its long history. The distinguished physicist **Renzo Macii** explained that the development of techniques for astronomical and meteorological observation have gone hand in hand at Ximeniano, since knowing the position of the sun and planets was indispensable for accurate time-keeping, and accurate time-keeping was in turn critical for maintaining precise meteorological records. In addition to the telescopes, theodolites, and meteorological instruments – many of which were made on site, another fascinating collection showcases the evolution of seismological instruments, which were also developed and employed at Ximeniano since 1873.

The observatory also houses two libraries, one of which is lined with volumes of meteorological data. Over the entire time series starting in 1813, the extremes of temperature registered include a minimum of -12.9°C on December 30, 1849 and a maximum of 41.6°C on July 26, 1983.

The Ximeniano record of air temperature was analyzed by Kumar et al. (2005, Climatic Change 72: 123–150), and shown to exhibit significant long-term warming (about 0.1°C per decade) between 1889-1998. Over the past half-century this rise in mean temperature has accelerated, and the *minimum* temperature has been seen to increase more steeply at Ximeniano than at a rural station 6 km away.

Ximeniano is not a museum – it is a living institution that still performs routine measurements and takes part in the development of knowledge in the field of meteorology. In marking the start of Ximeniano's third century of operation, the organizers of last year's conference aimed to "celebrate and emphasize its importance for our city, and to remember and thank the colleagues who in the last two centuries have worked in this institution."

-- *David Pearlmutter*

One of the rare artifacts housed in the observatory is a model of the world's first internal combustion engine, invented in the mid-19th century by Barsanti & Matteuci and reproduced some 150 years later by Renzo Macii (left).

Recent publications in Urban Climatology

In this edition a list of publications are presented that have come out between June and August 2014. As usual, papers published since this date are welcome for inclusion in the next newsletter and IAUC online database. Please send your references to the email address below with a header "IAUC publications" and the following format: Author, Title, Journal, Volume, Pages, Dates, Keywords, Language, URL, and Abstract. In order to make the lives of the Bibliography Committee members slightly more easy, please send the references in a .bib format.

Since a number of bibliography committee members have resigned, we are supporting (young) researchers to join this effort and contribute to the Committee. If you are interested to join or you want more information, please let me know via the email address below.

Regards,

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Adams, M. P. & Smith, P. L. (2014), A systematic approach to model the influence of the type and density of vegetation cover on urban heat using remote sensing, *Landscape and Urban Planning* **132**(0), 47-54.

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Upcoming Conferences...

URBANIZATION AND GLOBAL ENVIRONMENTAL CHANGE (UGEC)
Taipei, Taiwan • November 6-8, 2014
http://www.ugec2014.org/

DRYLANDS, DESERTS AND DESERTIFICATION (DDD 2014)
Sede Boqer, Israel • November 17-20, 2014
http://in.bgu.ac.il/en/desertification

PASSIVE AND LOW-ENERGY ARCHITECTURE (PLEA 2014)
Ahmedabad, India • December 16-18, 2014
http://www.plea2014.in/

INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC9)
Toulouse, France • July 20-24, 2015
http://www.meteo.fr/icuc9/

Meet the three new members of the IAUC Board

As reported in the last issue of *Urban Climate News*, three new members have been elected to serve on the Board of the IAUC. Here is some background on the latest trio to join the Board.

Fei Chen

Fei Chen is Senior Scientist and leads the Land-Atmosphere Interaction and Modeling group in the Research Application Laboratory, National Center for Atmospheric Research (NCAR), Boulder, Colorado, USA. He received a Ph.D. in Atmospheric Sciences at the Blaise Pascal University, in Clermont-Ferrand, France.

He has been studying the role of cities in regional weather, climate, and air quality through the use of observations and model simulations. He led an international collaborative effort to develop the integrated urban modeling system for the Weather Research and Forecasting (known as WRF-Urban) community. From 2011-2013, he was Chair of the Board on the Urban Environment of the American Meteorological Society (AMS). His research articles are listed at: http://www.researcherid.com/rid/B-1747-2009.

Edward Ng

Edward Ng is an Architect and Yao Ling Sun Professor of Architecture in the Chinese University of Hong Kong (CUHK). He obtained his PhD from Cambridge University, and worked as an architect before becoming a professor. He specializes in Green Building, Environmental and Sustainable Design and Urban Climatology for City Planning.

At CUHK, he is the Director of the M.Sc. Sustainable and Environmental Design Programme, the Associate Director of the Institute of Future Cities (IOFC) and the Team Leader of Urban Sustainability and Public Health in the Institute of Energy, Environment and Sustainability (IEES). As an environmental consultant to the Hong Kong SAR Government, Edward developed the performance based daylight design practice note; the Air Ventilation Assessment (AVA) Technical Guidelines; and the Urban Climatic Maps for City Planning for the HKSAR Govt. He is now working with governments and agencies in Singapore, Macau, as well as a number of Chinese cities on the same. Among many of his research interests, he is collaborating with public health colleagues to investigate the impact of city design and climate change on urban living.

Professor Ng has published over 400 papers and reports, including 3 books. He has twice received the International Award from of the Royal Institute of British Architects (RIBA), he has also twice been given the UNESCO Asia Pacific Heritage Jury Commendation for Innovation Award. He was the recipient of the Red Cross Humanitarian 2010 Award. He was named one of the Asian of the Year by Reader's Digest in 2011.

Nigel Tapper

Nigel Tapper holds a Personal Chair in Environmental Science at Monash University, Australia where he currently leads the Applied Climate Research Group within the Monash Weather and Climate (MWAC) Program. Nigel is Co-Leader Program B (Water Sensitive Urbanism) and a key researcher in the new Cooperative Research Centre for Water Sensitive Cities that was established in 2012. Nigel is also a Director (Urban Climate) of the Monash Water for Liveability Centre. He has contributed to the work of the IPCC (as an Expert Reviewer and as a contributor to the Expert Panel on Infrastructure and Settlements) and to the work of ICSU/IGU as the Chair of the National Committee for Geography of the Australian Academy of Science.

In his research activity Nigel has been involved in publishing seven books, 11 book chapters and approximately 200 refereed research publications, and has supervised 30 Ph.D. students. With Andrew Sturman, Nigel co-authored the classic text on Australasian climate – *The Weather and Climate of Australia and New Zealand*. His early work was in urban climatology, but since 1981 he has undertaken fundamental research on surface-atmosphere interaction, focusing on the role of surface inhomogeneities in developing meso-scale atmospheric circulations. Key elements in recent years have been in weather and climate impacts, including fire, ecosystem and human health-climate interactions. A strong climate change adaptation theme has emerged in this research, especially in relation to urban environments and human health. Much of this work has focused on delivering industry-relevant research that will influence design of cities of the future.

ICUC9 in Toulouse, France: Call for Abstracts

The joint 9th International Conference on Urban Climate and 12th Symposium on the Urban Environment (SUE), sponsored by the International Association for Urban Climate and the American Meteorological Society, will be held in Toulouse, France, 20-24 July 2015.

In the year of the 21st session of the Conference of the Parties on Climate Change Policy & Practice, the focus of ICUC9 will be put on the recent scientific activities on Climate change mitigation & adaptation in urban environments, as well as on the transfer to institutional stakeholders urban planners to include urban climate considerations in their practices.

Of course, traditional topics covered by ICUC and SUE and related to advances in observations, modeling, and applications are also eligible. Any papers and posters on subjects dealing with urban climate issues are welcome.

The conference topics include, but are not limited to :

Climate change mitigation & adaptation in urban environments

- Cities in climate models (global and regional scales)
- Climate services for cities
- Forecasting and impacts of extreme weather events in cities
- Adaptation/mitigation strategies (e.g. urban greening)
- Incentives for adoption/implementation of mitigation and adaptation plans

Transfer of urban climate knowledge to urban planners

- Urban weather forecasting
- Indicators and climate maps
- Storm surges and flooding maps
- Warning plans
- Public policies
- Amendment / development of planning regulations

Study of urban climate processes

- Boundary layer and canopy layer Urban Heat Islands
- Surface and subsurface Urban Heat Islands
- Surface energy and water balances
- Greenhouse gases in the urban environment
- Flows and dispersion in the urban canopy layer
- Precipitation/fog/clouds
- Air quality/aerosols/radiative transfers in the urban boundary layer
- Influence of urban vegetation

Geospatial datasets

- Urban climatology studies
- New remote sensing technologies and data
- Local Climate Zones
- Urban database and link with models

New observational and modeling techniques and methods to study urban climates

- Field campaigns, sensor and network development
- Wind tunnel & hardware model experiments
- Statistical models
- CFD/LES/Dispersion models
- Numerical weather prediction and mesoscale modeling
- Urban canopy parameterizations

Bioclimatology and public health

- Outdoor microclimate and comfort
- Indoor comfort & air quality
- Human perception
- Climate resilient design

Urban design with climate

- Building climates
- Energy supply and demand in cities - the role of urban climates
- Sustainable design practices
- Morphological urban design

Urban planning with climate

- Enhancement/amendment of urban zoning
- Governance challenges for tackling urban heat

Interdisciplinarity

- Hydrology and floods in link with urban climates
- Biodiversity
- Link with social and human sciences

ICUC9 Call for Abstracts (cont.)

Submission Deadlines

Opened: Tuesday, July 22, 2014

Closes: Monday, December 1, 2014

23:59 pm Central Europe Time

Notification: Early February 2015

Helpful Information

Abstracts for the 9th International Conference on Urban Climate need to be submitted according to the instructions that appear in the official Call for Abstracts. Only those abstracts submitted via the official submission website will be considered. There is no cost for submitting an abstract.

All abstract submissions will be peer reviewed and may be submitted as an oral presentation and/or a poster presentation. Each abstract should represent complete and original results. As in previous ICUC, authors are limited to participation as "Presenter" in a maximum of ONE (1) abstract submissions.

For additional scientific information please contact the local scientific commitee (Valéry Masson and Aude Lemonsu) at : icuc9@meteo.fr

For any technical information on the submission procedure, please contact :

icuc9.secretary@meteo.fr

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- Nigel Tapper (Monash University, Australia): 2014-2018

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Newsletter Contributions

The next edition of ***Urban Climate News*** will appear in late December. Items to be considered for the upcoming issue should be received by **November 30, 2014** and may be sent to Editor David Pearlmutter (davidp@bgu.ac.il) or to the relevant section editor:

News: Winston Chow (winstonchow@nus.edu.sg)

Conferences: Jamie Voogt (javoogt@uwo.ca)

Bibliography: Matthias Demuzere (matthias.demuzere@ees.kuleuven.be)

Projects: Sue Grimmond (Sue.Grimmond@kcl.ac.uk)

Submissions should be concise and accessible to a wide audience. The articles in this Newsletter are unrefereed, and their appearance does not constitute formal publication; they should not be used or cited otherwise.