From the IAUC President

Welcome to the June 2018 edition of the Urban Climate News.

The IAUC is pleased to announce that we have adopted a new diversity statement. It reads: “The International Association for Urban Climate (IAUC) is committed to, and promotes inclusive and equitable participation of a diverse community in its membership and activities including publications, meetings, conferences, awards and honors.” IAUC’s membership database shows that just over half of our members are female, but this representation does not extend through all of IAUC’s activities. This initiative should help guide both IAUC and future ICUCs as they seek to identify Board Members, invited speakers, panelists and award winners.

In support of this initiative, a web resource https://500womenscientists.org/ has been identified that we believe will provide a useful tool for IAUC to help address diversity in identifying invited speakers. The Request a Woman Scientist platform connects to that organization’s network of vetted women in science. It provides a searchable database to help identify relevant women scientists for scientific collaboration, when consulting for a news story, identifying keynote speakers or panelists, or for serving as a subject matter expert. I encourage our female members to sign up with this site. The site also allows researchers to choose up to three disciplines and add ‘urban’ to the keywords; this broadens the range of subdisciplines that can be represented within the tool.

To help celebrate and raise awareness of this statement, IAUC will be hosting a Diversity and Equality on Urban Climate event at ICUC-10 Monday Aug 6 from 5:30-7:00pm. This open event will include a presentation on the importance of the topic and the background for the new Diversity statement, an overview of the 500 Women Scientists web resource and an open discussion on what the IAUC community can do to enhance equality within the community.

And speaking of ICUC-10, the organizers now report that nearly 500 registrations have been received for the conference. The conference program is available on the web and a more detailed report is available on p.36. At its meeting just prior to ICUC-10, the Board expects to hear proposals from four groups representing Beijing, Hong Kong, Sao Paulo and Sydney on hosting ICUC-11. As in past years, we will be sharing summary information on the proposals and conducting an online preference survey of all IAUC members as part of the selection process. For further details, see the report on the ICUC-11 selection process on p.37.

Finally, the Board meeting at ICUC-10 will mark the changeover to a new IAUC Executive. We welcome Nigel Tapper (Monash University) who will become President and Andreas Christen (Universität Freiburg) who takes on the position of IAUC Secretary. Congratulations to Nigel and Andreas and I know they will do a great job. Thanks to Emmanuel Rohinton and David Sailor in their roles for helping with the election process.

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36 IAUC Board: ICUC-10 in New York City Four finalists propose to host ICUC-11
Six research priorities for cities and climate change

Xuemei Bai and colleagues call for long-term, cross-disciplinary studies to reduce carbon emissions and urban risks from global warming.

February 2018 — Cities must address climate change. More than half of the world's population is urban, and cities emit 75% of all carbon dioxide from energy use.

Meeting the target of the 2015 Paris climate agreement to keep warming well below 2°C above pre-industrial levels requires staying within a 'carbon budget' and emitting no more than around 800 gigatonnes of CO₂ in total after 2017. Yet bringing the rest of the world up to the same infrastructure level as developed countries (those listed as Annex 1 to the Kyoto Protocol) by 2050 could take up to 350 gigatonnes of the remaining global carbon budget.

Much of this growth will be in cities in the developing world (see ‘Urban development challenge’).

Cities are increasingly feeling the effects of extreme weather. Many are located on floodplains, in dry areas or on coasts. In 2017, more than 1,000 people died and 45 million people lost homes, livelihoods and services when severe floods hit southeast Asian cities, including Dhaka in Bangladesh and Mumbai in India. California’s suburbs and Rio de Janeiro in Brazil have experienced floods and mudslides on the heels of drought, wildfires and heavy rains. Cape Town in South Africa has endured extreme drought since 2015. By 2030, millions of people and US$4 trillion of assets will be at risk from such events (see go.nature.com/2sbj4qh).

In response, the science of cities is evolving. Urban planners and decision-makers need evidence to help them manage risks and develop strategies for climate mitigation and adaptation. Scientists are increasingly thinking of cities as complex systems and working more closely with communities. New concepts are emerging, such as smart cities.

Yet the scope and applicability of urban research is stymied: a lack of long-term studies of urban climates and their impacts makes it hard for city officials to plan decades ahead. And research grants focused on single disciplines or local or national needs provide little scope for cross-disciplinary projects or comparative analyses between regions. Few online platforms exist to help cities share information and learn from one another.

Science needs to have a stronger role in urban policy and practice. In Edmonton, Canada, the Intergovernmental Panel on Climate Change (IPCC) and 9 global partners [brought] together some 700 researchers, policymakers and practitioners from 80 countries for the IPCC Cities and Climate Change Science Conference (https://citiesipcc.org). Participants establish[ed] a global research agenda that will inform the IPCC special report on cities — part of the panel’s seventh assessment cycle, which begins in 2023.

Knowledge gaps

Mitigating and adapting to urban climate change will require work in several areas.

Expand observations — Researchers and city authorities need evidence to help them manage risks and develop strategies for climate mitigation and adaptation. Scientists are increasingly thinking of cities as complex systems and working more closely with communities. New concepts are emerging, such as smart cities.

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As members of the scientific steering committee for the IPCC conference, here we identify six priorities for cities and climate-change research.

The coastal city of San Juan in Puerto Rico was flooded after Hurricane Maria hit in September 2017. Source: https://www.nature.com
Narratives and local knowledge must be assimilated with technical data. Old neighbourhoods in Kano, Nigeria, have proved more resilient to floods and heat than have developments built after 1980. Flat mud roofs are better at absorbing and evaporating rainwater than are metal or concrete. And Nigerian cities have historically included many open spaces, green areas and wetlands.

A global network of ‘urban observatories’ – diverse cities that are focal points for research and long-term monitoring – is needed. Data, research and practice should be shared online. In the United Kingdom, Newcastle University collects 1 million measurements a day from sensors across the city and makes them openly available online in real time. These range from transport emissions, precipitation, water flows and air qualities to biodiversity measures such as bee hive weight. The city council and the transport, energy, environmental and water sectors are using the data. Similar observatories are being developed in Sheffield and Bristol.

To ensure trust, such data need to be verifiable and used transparently. Researchers and practitioners need to develop mechanisms for governance, security, ethics and engagement. There are privacy and security concerns; for example, many cities are now legally required to protect private data. Some are reticent to publish information that might reveal they failed to meet targets.

**Understand climate interactions** — Climate processes are complex – more so in cities. For example, urban air pollution in Chinese cities is causing heavier rainfall as fine particles influence clouds. Impermeable surfaces, such as concrete or asphalt, hold heat and reduce evaporative cooling, amplifying urban ‘heat islands’.

Comparative studies are needed of cities in different contexts to disentangle these interactions and to find solutions. We need to know how urban morphologies, building materials and human activities affect atmospheric circulation, heat and light radiation, urban energy and water budgets. How much permeable paving is needed to lower flood risk, as Melbourne is doing with bluestone pavements? What is the impact of reflective roads and roofs, as tried in New York and Los Angeles?

Climate simulations need to account for urbanization, and be scaled down to city and neighbourhood levels. Methodologies for high-resolution risk assessment of heatwaves, coastal erosion and inundation are needed. Different approaches and models need to be compared, benchmarked and coupled with assessments of local social vulnerabilities and capabilities.

**Study informal settlements** — By 2050, three billion people, mostly in the global south, will be living in slums; neighbourhoods that have no mainstream governance, on land that is not zoned for development and in places that are exposed to climate-related hazards such as floods. Poor housing and basic services compound the risks for individuals and households.

Enabling these communities to adapt is a priority. Assessments are needed of grass-roots efforts to address hazards. For example, community-based organizations are buying land outside flood zones and constructing resilient housing in the Philippines, and mapping flood risk in Gorakhpur, India. Such studies should look at formal and informal relationships and include voices from marginalized groups.

Models and analytical tools tailored to these communities need to be developed, because the approaches used in cities in the global north cannot be transplanted. Data scarcity, informal socio-economic processes and limited local capacities must be considered.

Policies need to be assessed. For example, the cities of Adama and Mekele in Ethiopia boosted affordable housing around their peripheries by increasing the area of land available for development. Keeping land tenure in government hands saves effort in the long run; large networks of infrastructure and public spaces can be planned and built coherently, without having to retrofit poorly designed areas. Informal settlements may have lessons for sustainability. Residents are often efficient at using scarce resources and reusing and recycling waste. Mitigation efforts need to support, rather than undermine, livelihoods and human well-being as well as the informal economy.

**Harness disruptive technologies** — The digital revolution is transforming cities. For example, urban shared-mobility schemes have improved air quality and social inclusion, and reduced congestion. In Lisbon, for instance, studies have shown that a fleet of shared taxis could maintain residency levels using only 3% of the current number of vehicles. Global adoption of shared, automated electric
vehicles could cut world’s vehicle stocks by one-third.

Yet these benefits could be reduced if the ease of using such technologies ultimately led to increased vehicle use. Researchers need to understand what drives positive and negative outcomes, as well as how to influence them – such as by enabling more shared travel through information and communication technologies.

Digitally connecting and controlling water, power, communications and transport systems increases the likelihood that climate hazards will affect such networks simultaneously. These coupled risks – and where responsibilities lie – are poorly understood. Outages cascade and lead to shortages of food, cash and fuel, as happened in New York after Hurricane Sandy in 2012.

Affordable materials and technologies that can reduce the carbon intensity of future infrastructure in the global south should be developed and commercialized. For example, cement can be engineered to absorb more CO₂. Cement production is the third-largest human-made source of emissions after fossil-fuel burning and land-use change, contributing around 5.6% of global fossil-fuel and industry-related CO₂ emissions. ‘Carbon-neutral’ timber and bamboo have been used to build lightweight skyscrapers. These materials need to be sustainably produced at low cost. The C40’s Climate Positive Development Program is experimenting in 18 cities to achieve net-negative emissions in mixed-development projects of up to 300,000 people.

Vegetation corridors, green parks, reed beds and low-lying areas that soak up water can be woven into the built environment to reduce flood and heat risks, while improving biodiversity and carbon storage. More needs to be known about the long-term performance and management of such features. Design and engineering standards need to be developed.

Support transformation — Bold strategies are needed for achieving low-carbon, resilient cities. For example, China’s ‘sponge city’ initiative helps to reduce urban flood risks by increasing green spaces, restoring wetlands and using permeable materials to absorb rainwater and delay runoff. More needs to be learned about how to change residents’ lifestyles and consumption patterns, through policies and incentives, to make zero-carbon neighbourhoods and cities.

A start is to find and scale up successful local innovations. For example, Shanghai is experimenting with a range of low-carbon practices, including district heating networks, carbon labelling of consumer products and financial mechanisms. Research and policy frameworks need to be developed to translate successful local innovations across cities.

Recognize global sustainability context — Cities are open, complex, dynamic systems with a global reach. Well-intended local actions can displace issues to other sectors or into the future. For example, one city’s crack-down on energy-intensive production might shift the problem to less-regulated regions, with no net gain on emissions reduction. Many cities in China, South Korea and Vietnam have relocated industries outside the city to improve their environmental ratings.

A systems approach is needed to deliver on global climate change as well as the UN’s New Urban Agenda and Sustainable Development Goals. More needs to be known about interactions, trade-offs and synergies between urban processes and their impacts elsewhere. This entails working across disciplines and governance silos. ‘Nexus approaches’ that trace linkages between water, food and energy systems should be extended to other sectors, to understand the relationships between infrastructure provision, in–equality and resilience, for example.

Next steps

Researchers, policymakers, practitioners and other city stakeholders need to strengthen partnerships and produce knowledge together. Universities should support data platforms and long-term research programmes in their cities, while sharing knowledge nationally and internationally. Scientists should become more engaged with policy and practice networks such as C40 Cities, ICLEI Local Governments for Sustainability and United Cities and Local Governments.

We would like to see cities establish scientific advisory boards chaired by a chief science adviser, as many government departments do. These would enhance the profile of science, build capacity and leadership, and provide a point of contact.

Funding agencies need to provide grants for cross-disciplinary research and comparative studies, especially in the global south. Cities might mandate that companies bidding for large-scale government projects in renewable energy or sustainable transport, for example, contribute money for related university research, as is required in the Australian Capital Territory. Cities should develop business models and partnerships to accelerate successful experiments and scale up ideas and technologies.

Online platforms must go beyond data sharing to help researchers, policymakers, practitioners and citizens diagnose problems, generate solutions, trial and evaluate their effectiveness and embed learning. Future Earth’s Urban Knowledge-Action Network shares this ambition, but requires stable financial and institutional support to support cities globally in the long term.

Research and innovation for mitigating urban climate change and adapting to it must be supported at a scale that is commensurate with the magnitude of the problem.

The impact a year after the U.S. left the Paris agreement

Climate Mayors: Assessing the effectiveness of city leadership on the climate

May 2018 — Last June, during a press conference in the Rose Garden, President Trump announced the United States would be leaving the Paris climate accord, seeking a better deal for the country and more control over its own destiny.

It was a low point for environmentalists in the United States. As soon as Trump stepped to the podium, the country symbolically stepped away from its leadership role.

But almost instantaneously, other politicians filled the vacuum. Hundreds of city leaders pledged to live up to the Paris agreement and signed on as members of the Climate Mayors, a bipartisan, peer-to-peer network of mayors working to demonstrate leadership on climate change.

The coalition, which now boasts 405 members representing 70 million Americans, was one of the most visible in a growing list of coalitions and organizations seeking to demonstrate U.S. commitment to fighting climate change and lowering emissions. Along with We Are Still In (a group of corporations and civic leaders), C40 (an international group of mayors united to enact progressive climate policy), Ready for 100 (a Sierra Club campaign pushing renewable power), and others, the Climate Mayors pushed back against the narrative that the U.S. is abandoning its commitments, and embodied the grassroots energy for change.

But a year later, how should the organization’s accomplishments be evaluated? The “come as you are” ethos to membership eschews additional strict commitments in favor of building a community.

At a time when climate change, and the costs of increased temperatures and more extreme weather, are clear, does a group claiming to represent bipartisan action need to set the bar higher? Have they, for example, done enough to tackle carbon emissions from cars and transportation?

How city-led political coalitions can make an impact

According to a new study that examines the growth of city-led, issue-based coalitions, groups like Climate Mayors serve a very important purpose. At Boston University’s Cities Initiative, executive director Katharine Lusk and research fellow Nicolas Gunkel recently co-authored a report, “Cities Joining Ranks,” studying these groups. The report looked at 15 different organizations, 10 focused on environmental issues and one each pertaining to immigrant inclusion, gun violence, violence involving men and boys of color, volunteering, and broadband access.

In addition to filling a leadership vacuum at the federal level – one of the most frequent arguments for starting such groups – these coalitions also provide “strength in numbers,” according to a survey of mayors conducted by Lusk and Gunkel.

“They view critical mass as being key to amplifying their voices to influence other levels of government,” says Lusk. “In other words, they stand together to influence others and signal their priorities rather than gain support for a specific policy.”

Lauren Faber, the chief sustainability officer for Los Angeles, said putting together a group like the Climate Mayors was a goal for Los Angeles’ own city leadership.

“Leading and growing a coalition has been a big part of LA’s plan, and municipal support for strong climate action has been a goal for Mayor Eric Garcetti,” she says. “I think he understands that, in forming such a group, it creates the right momentum around an issue, and an enhanced ability to act.”

Meeting cities where they’re at, and encouraging them to create, enact, and realize their own climate goals, offers a better chance for overall success, according to Faber, for both the coalition and the country at large.

“There are no emissions targets or climate action plans because that’s a barrier to entry for this collective,” she says. “This way, we’re able to engage so many more cities that may lack some of the resources to do these things.”

On March 9, the number of Climate Mayors members reached 400. Source: https://twitter.com/ClimateMayors

Meeting the climate challenges in the Trump era

Climate Mayors, also known as the Mayors National Climate Action Agenda, existed before President Trump pulled out of the Paris Climate Accord. It was formed in 2014 when Mayor Garcetti, then-Houston Mayor Annise Parker and then-Philadelphia Mayor Michael Nutter announced its creation during a United Nations climate summit in New York City. Much of the group’s activities are coordinated out of Los Angeles, where the city’s sustainability office organizes and directs meetings and information sharing between members.

While the group, and others such as C40, has existed for years, they “took on a new flavor,” in the Trump era, says Faber. The expansion of these city climate coalitions coincides with a renewed focused by advocates and activists on local action.

After the 2016 election, the coalition reached out to the President-elect, writing a letter outlining the ways the group had worked with the previous administration, and asking to be a partner with the White House on fighting climate change.

But after withdrawal, it was important to take a stand.

India Delhi residents choke as dust blankets capital

June 2018 — Residents of India’s capital Delhi are battling high pollution levels and extreme temperatures due to an unusual dust haze covering the city.

People have been complaining about breathing problems, with many saying the city has become unliveable.

The state government has responded by banning all construction and deploying the fire brigade to sprinkle water across the city. People have been advised to stay indoors as much as possible.

“In this case, dust has become a carrier of toxic pollutants. Pollution levels are 8-9 times higher than normal. And when we breathe, we are taking in toxic substances, which can have serious health repercussions,” Anumita Roy Chowdhury, executive director of the Centre For Science and Environment, told BBC Hindi.

Delhi is already one of the most polluted cities in the world, but the recent weather pattern has caused more problems for its residents. Many have taken to social media to share their concerns and are urging the government to do something about it.

Experts say dust storms originating from the nearby desert state of Rajasthan are to blame. “This phenomenon is not uncommon in the pre-monsoon season,” Dr Kuldeep Srivastava of the meteorological department told the BBC. “But this time the haze has stayed unusually lon-ger because of the delay in the arrival of seasonal monsoon rains.”

The air quality worsens every year in November and December as farmers in the neighbouring states of Punjab and Haryana burn crop stubble to clear their fields.

Pollution levels reached 30 times the World Health Organization’s safe limits in some areas of Delhi last year. The air quality improved in the following months, but has gone back to “severe” from “moderate” in June this year.


A thick blanket of dust has added to the woes of the city.


This image was acquired on June 14 by the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite. The dust was trapped between mountain ranges and appears in the shape of upside down “v” on the image. Source: [https://earthobservatory.nasa.gov/IOTD/view.php?id=92309](https://earthobservatory.nasa.gov/IOTD/view.php?id=92309)
World Cup 2018 in Russia: What about the weather?

The 2018 FIFA World Cup is underway in Russia. But while the players compete for World Cup glory, there is one element that remains completely out of their control: the weather.

Held in 11 host cities across Russia, there are 1,550 miles between the two furthest FIFA 2018 destinations – Kaliningrad in the west, and Yekaterinburg in the east – meaning there could be great diversity of weather happening across the event.

And, while this time of year tends to be warm and on the drier side, rain, thunderstorms and sometimes even tornadoes can occur.

“Much like across the United States, there is the occasional frontal passage to bring cooling as well as some rain and thunderstorms on occasion,” AccuWeather’s Senior Meteorologist Jason Nicholls said.

“Strong to severe thunderstorms with downpours, hail and strong winds are not uncommon.”

So, what kinds of temperatures can players and football fans expect?

**Volgograd**
Set to be the warmest of all the host cities, Volgograd has an average June high of 26.6°C and an average July high of 29.3°C. Monthly rainfall is about 41mm in June and about 35mm in July.

**Rostov-on-Don**
On average, Rostov-on-Don sees highs of 26.6°C in June and an average July high of 29.2°C. Monthly rainfall is greater here with 70mm in June and 53mm in July.

**Sochi**
Football fans visiting Sochi can expect warm temperatures with an average June high of 24.6°C and an average July high of 27.4°C. However, they should also prepare for showers as it has the highest monthly rainfall with 104mm in June and 128mm in July.

**Samara**
Samara has an average June high of 25.3°C and an average July high of 26.9°C. Monthly rainfall is about 56mm in June and about 57mm in July.

**Kazan**
Kazan looks set to stay fine too with an average June high of 23.6°C and an average July high of 25.5°C. On average the monthly rainfall in June reaches 63mm and 67mm in July.

**Nizhny Novgorod**
Nizhny Novgorod has an average high in June of 22.6°C and in July of 24.7°C, but it has previously seen record temperatures of 38.2°C. Monthly rainfall is slightly higher, at about 76mm in June and about 73mm in July.

**Ekaterinburg**
Ekaterinburg has an average June high of 23°C and an average July high of 24.4°C. Monthly rainfall is about 75mm in June and can reach up to 90mm in July.

**Moscow**
Moscow, which see World Cup matches play out at the Spartak Stadium and Luzhniki Stadium, has an average June high of 22°C and an average July high of 24.3°C. Monthly rainfall is about 80mm in June and 85mm in July.

**Saransk**
While still warm, Saransk is one of the cooler destinations with an average June high of 22.3°C and 23.9°C in July. Average monthly rainfall is 59mm in June and can reach up to 74mm in July.

**Saint Petersburg**
Saint Petersburg promises to stay warm with an average June high of 20°C and an average July high of 23°C. However, there is a chance of rain with an average monthly rainfall of 71mm in June and 67mm in July.

**Kaliningrad**
Temperatures are similar in Kaliningrad too with an average high of 20.5°C in June and 23°C in July. Monthly rainfall is slightly higher here though with about 79mm in June and 77mm in July.

Micrometeorology of an ephemeral city: the Burning Man experiment

By Andrew Oliphant*, Garrett Bradford, Malori Redman, Ryan Thorp, Sam Stein, Lewis Ames

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Introduction

Urbanization impacts the climate system in multifaceted ways through alteration of airflow, and exchanges of radiation, heat, water and greenhouse gasses. Observations over a range of city types and sizes as well as the eco-regions they inhabit have revealed consistent micrometeorological impacts, such as increases in the Bowen ratio and heat storage flux, increases in surface roughness parameters, as well as increasing sources and decreasing sinks for CO$_2$. In synthesis, these studies also show large inter-city and intra-city variability, driven by differences in the size, density and configuration of cities and differences in their biophysical environment.

To this observational record, we wanted to add a unique urban environment, Black Rock City (BRC), Nevada, USA, an ephemeral city that rises from a dried lake bed (playa) for the week-long Burning Man Festival, a gathering of art and cultural sharing (http://burningman.org). The city is unique in several ways that may contribute to our understanding of urban microclimates by comparison with results from more traditional cities. The first is that the site is arid, flat and devoid of vegetation for at least 5 km in every direction (Figs. 1 and 2). Thus the frictional properties of the surface are extremely small prior to the city and there are no sources or sinks of CO$_2$ from vegetation, no transpiration, and very little evaporation from the dry lakebed sediment. The second is that the city itself contains no concrete or paved surfaces (‘urban’ material in this context is primarily wooden structures, camping vehicles, tents, large shade structures and parked vehicles). Thirdly, transport within the city during the festival is almost entirely by bicycle or on foot, with large vehicle movements concentrated at either end of the festival during arrival and exodus of the population. Most importantly, the ephemeral nature of BRC provides the unusual opportunity to assess the micrometeorology of a city while it undergoes its full evolution from tiny settlement to dense city (~14,000 people/km$^2$) followed by rapid urban collapse and abandonment.

The experiment reported here was designed to capture the micrometeorological impacts of Black Rock City through its full evolution. In particular, we wanted to use this unique study site to target the following questions:

• How do surface frictional properties change as a function of urban density?
• How does BRC impact the surface energy balance? Does it produce an observable urban heat island?
• How can we isolate anthropogenic sources in measurements of the urban carbon cycle?
• What would be the effect on carbon emissions of restricting transport to walking and bicycling in neighborhoods?
• What can micrometeorology offer art?

In addition, the findings from this study may be more directly applicable to other temporary or informal settlements such as refugee camps, shanty towns or favelas due to similarities in building heights, density and ma-
terials, lack of paving, limited vehicular transport, and in many cases, localized energy generation. According to the United Nations High Commission for Refugees, in summer 2013 (during this experiment), about half of the 34 million registered refugees and internally displaced people were housed in refugee camps, and according to the United Nations Habitat Program, a further 860 million lived in ‘urban slums’ globally.

The City and the Experiment

Deployment of instruments began a week prior to the start of the festival, when special projects that require substantial build time get permission to enter and set up. After the gates opened at the start of the festival, the population rapidly swelled to a peak of 70,000 within five days. The principal experimental infrastructure was a 27.5 m micro-meteorological tower, which was deployed on the playa in what was to become the center of a densely packed residential neighborhood of BRC one week later (Fig. 1 and Fig. 2). A second 2.5 m mast was installed over the bare playa surface on the outskirts of the city (with prevailing winds from the open playa) and a third bicycle-mounted 2.4 m mast was used to obtain cross sectional temperature profiles of the city (Fig. 1). The bicycle mast supported six levels of fine-wire thermocouples and a thermal infrared radiometer oriented toward the surface. The main tower contained a six-level profile of temperature, relative humidity and horizontal winds, with an eddy covariance system mounted at 12 m. This included a three-dimensional sonic anemometer (CSAT3), and a high frequency open path gas analyzer for CO₂ and H₂O concentrations (LI-7500). The tower system is fixed to and deployed from a mobile trailer unit which is part of the California State University Mobile Atmospheric Profiling System (CSU-MAPS), described more completely in Clements and Oliphant (2014). Full deployment details for the Burning Man Experiment are provided in Oliphant et al. (2017).

In order to provide a check on observed CO₂ fluxes and to help interpret likely sources, an inventory approach
was used to independently estimate CO₂ emissions. This modeling strategy estimates CO₂ sources and sinks based on inventories of land surface type, census data, traffic counts, and other data unique to the site (Kellet et al., 2013). Assuming gross primary production and autotrophic respiration by vegetation was negligible, sources of CO₂ from the urban surface were therefore divided into three anthropogenic sources: metabolic, stationary, and mobile sources. The data used to make these estimates primarily came from the annual report of the Burning Man organization (Afterburn Report 2013) including a census report detailing population changes as well as transportation and energy consumption surveys of attendees.

The art of micrometeorology

An important part of the Burning Man culture is a sharing economy (interpreted widely), whereby each camp shares something unique freely to fellow citizens. ‘Camps’ vary widely in definition, containing from a few to a few hundred people. Our project, ‘Camp Antenna’, included about 40 people, with five researchers directly involved in urban micrometeorology, and the others involved in a variety of ways to share our project ideas and to blur the experiences of science and art. For example, 10 Hz three-dimensional wind velocity voltage analogue signals from the sonic anemometer were delivered to an Arduino microcontroller, which converted them to a digital signal for input to sound engineering software (Max-MSP). San Francisco Bay Area musician Lewis Ames then created music from the raw 10 Hz turbulence data. He provided a framework of rhythm and some control on sequencing of oscillators to keep the result more or less musical, although the note choice, timbre and effects of 10 different oscillators were controlled completely by the three wind components to create ‘turbulence music’. Links to the music can be found at http://online.sfsu.edu/andrewo/BRC2013.htm. In addition, a Total Control lighting system on the tower guys produced a chaser sequence at night, the speed of which was controlled by real-time wind speed, and a projector displayed live 10-Hz data graphics from the sonic anemometer and gas analyzer on a building sidewall (Fig. 3). On three of the festival nights we hosted open parties featuring turbulence music and light displays, presentations of observations and urban climate discussions. Of course meteorology-themed cocktails were served and alcohol was poured from a working Galileo Thermometer.

Results

The main findings derived from the dataset captured during the Burning Man experiment include; (1) analysis of modification of the surface layer wind profile and surface roughness characteristics, (2) evaluation of the urban heat island and changes to the surface energy balance, and (3) assessment of CO₂ emissions patterns through the evolution of the city, and estimates of the breakdown of component sources. Here, we will briefly

Figure 2. Images captured from the top of the flux tower facing south (a, c) and near ground level showing the tower area (b, d), prior to the start of the event (a, b) and during the peak (c, d), as well as the small playa meteor station (e) and the mobile temperature profiler (f) operated by Malori Redman in the central playa near the eastern extent of the transect with the Burning Man central art piece ‘The Man’ in the distance (see Fig. 1 for locations).
summarize and highlight some results from each topic and point the reader to further sources, should they wish to pursue more detail.

**Urban modification of surface layer winds**

Wind profiles in the atmospheric surface layer showed overall reductions in wind speed through the lower 27.5 m and agreed approximately with Monin-Obukov logarithmic wind profiles (Fig. 4a). Roughness length in this case was estimated by extrapolating the logarithmic wind profile from two observational heights in the inertial sublayer to the height at which wind speed reached zero for 30-minute cases of near-neutral stability. This height is the sum of zero plane displacement height ($z_d$) and roughness length ($z_0$) and was found to nearly double between periods prior to the festival (0.24 m) and during the fully developed city (0.45 m) (Oliphant et al. 2017). An increase in $z_d$ was separately found using the anemometric technique of Rooney (2001) as well as an increase in $z_0$ estimated by the eddy stress method (Grimmond et al. 1998). According to the morphometric model of MacDonald et al. (1998) applied to BRC, $z_d$ peaked in the most densely packed neighborhoods to the south of the tower, but $z_0$ was relatively
smaller there, and highest in the lower density neighborhoods on the windward edge of the city (Fig. 4c and 4d, Bradford 2015). Over the evolution of the city, $z_0$ (determined morphometrically) increased sharply just prior to the start of the event and remained nearly constant throughout the event (Bradford 2015). In contrast, $z_d$ increased steadily throughout the study period. This shows that, as object density reaches a threshold, increasing the number of obstacles raises the momentum sink rather than increasing overall roughness. Overall, the fully-developed BRC produced roughness values similar to, but somewhat smaller than a suburban neighborhood of a more traditional city (Bradford 2015).

**Urban Heat Island**

Black Rock City did not produce an observable Urban Heat Island. UHI in this case was assessed by 30-minute temperature differences between the urban and playa measurement sites, as well as temperature profile differences from bicycle observations (Fig. 1). 30-minute UHI values throughout the festival were normally distributed, with a mode close to 0, and 80% of observations within ±0.5 °C (Redman 2014). Figure 5a shows this was true of all wind directions and Redman (2014) also showed that there was no diurnal pattern to UHI values and no correlation with wind speed. From the bicycle transects, although mean differences in temperature between urban and open playa sections were similarly negligible, the shape of the profile in the lower 2.5 m was consistently different. In the case shown in Figure 5b, the emerging nocturnal surface inversion is evident in both locations, and the mean temperature difference was less than 0.1 °C between the two locations. However, the inversion is much steeper in the open playa, with both lower temperatures near the surface and higher temperatures at 2.4 m. The impact of larger boundary layer eddies on temperature fluctuations (with periodicities of 5-10 seconds) is evident in both locations. However the more isothermal nature of the urban temperature profile suggests stronger mixing, presumably from smaller eddies generated by surrounding surface roughness elements.

To our knowledge, this is the only city where a regular UHI could not be determined at all from observations. Here, the uniqueness of BRC allows us to postulate causality of positive UHI’s observed elsewhere. First, the decrease in vegetation and available water for latent heat flux was not important in this case. There was no reduction in vegetation and arguably an increase in surface water available due to human activities. Other arid cities share this characteristic and yet show significant UHIs, including in Tuscon (Comrie 2000) and Phoenix (Hawkins et al. 2004), Arizona. In fact at BRC, a slight decrease in the Bowen ratio was observed after the city developed (Oliphant et al. 2017) as well as higher specific humidity inside the city (Redman 2014). Albedo also increased slightly as the city developed but the overall impact of BRC on the surface energy balance was negligible (Oliphant et al. 2017). The significant heat storage flux that traditional urban fabric produces seemed to be negligible in this case, as there was very little change in the surface energy balance residual before and during the festival, a lack of diurnal pattern in UHI, and a lack of positive sensible heat fluxes after sunset (Redman 2014). This suggests that heat storage is the key driver of UHIs in arid cities with traditional urban fabric.

Figure 5. (a) Urban Heat Island index plotted by wind direction, calculated from temperatures measured at 2.5 m at the flux tower in the city and on the open playa (from Redman 2014) and two 90-second windows of one-second temperature observations at six heights on the moving bicycle (b) within the city near the flux tower and (c) a few minutes later in the open playa windward of the city, near 8pm PDT.
Urban CO$_2$ fluxes

CO$_2$ fluxes were the surface-atmosphere exchange process most impacted by the presence of the city. These fluxes were almost always positive (indicating the surface was a net source of CO$_2$ to the atmosphere) though weakly negative on occasion at night (Fig. 6). Prior to the main influx of population, CO$_2$ fluxes were around 5.2 gC m$^{-2}$ d$^{-1}$ but rapidly rose fivefold over the next four days to a daily average during the event of 24.8 gC m$^{-2}$ d$^{-1}$. The daily flux peaked on the final day (33.3 gC m$^{-2}$ d$^{-1}$) when the main exodus from the city occurred as well as burning of flammable waste in burn barrels. These are high rates of CO$_2$ fluxes by global standards, similar to those observed in Mexico City, Mexico (Velasco et al. 2005) and central London, UK (Helfter et al. 2010). Results of the inventory-based model of daily CO$_2$ fluxes compared well with observed fluxes in both the general magnitude and inter-diurnal variability (Oliphant et al. 2017). Breaking down the model components and observing the diurnal characteristics of the observed fluxes lead us to conclude that the largest contributor of CO$_2$ is local combustion of fossil fuels for stationary sources of energy, primarily for air-conditioning units and secondarily for nighttime lights and music and other media. Mobile sources of CO$_2$ were very high during arrival to and exodus from the city. However, during the festival when the vast majority of the population moved by bicycle or on foot, daily total mobile sources accounted for the smallest contribution to emissions (even smaller than human metabolic sources), and CO$_2$ per capita was three times smaller than during the vehicle-dominant phases (Oliphant et al. 2017).

A curious cultural artifact also shows up in the data set. Each year, on the penultimate night of the event (August 31 in 2013), a massive wooden sculpture known as ‘The Man’ (pictured in Fig. 2f) is burned in the center of the playa. By tradition, almost all of the citizens of BRC gather for several hours around the sculpture to watch and celebrate the burning, and the city neighborhoods within the flux source area were quiet, dark and almost empty of people. The CO$_2$ flux clearly dipped through the evening hours from about 1800 to a low point at 2200 PDT, during the burning of The Man (Fig. 6). Following this, the CO$_2$ flux climbed sharply back to high levels as the population density rapidly climbed in the neighborhoods, and generators were turned on in large numbers for the final major night of festivities.

Conclusions

The objective of the experiment described here was to provide a unique ephemeral city to the urban micro-meteorological observational record, that of Black Rock City, Nevada. The changes to surface roughness properties, surface energy balance, urban heat island, as well as CO$_2$ fluxes were captured through the full evolution of a city over two weeks as 70,000 people gathered on a bare playa surface for the annual week-long Burning Man Festival, then rapidly dispersed immediately afterward. CO$_2$ fluxes changed the most over the evolution of the city, rising from very low values prior to the festival to rates large by global city standards, averaging 24.8 gC
m² d⁻¹ throughout the festival. Most of the CO₂ source during the festival was for local electricity generation, while transport sources peaked near the start and end of the festival (peak of 33.3 gC m⁻² d⁻¹ on the main departure day), with extremely low rates during the festival due to a culture of bicycling and walking. Black Rock City was not observed to generate an urban heat island effect. Surface energy balance observations over the full period changed very little, with little evident urban impact. This was in part due to the arid and vegetation-free nature of the playa environment which limited impact on the latent heat flux, and in part due to the lack of concrete and paving which limited impact on the storage heat flux compared with more traditional cities. Surface roughness was found to increase as a function of urban density by both anemometric and morphometric methods, with zero plane displacement rising from near-zero to peak at about 1.9 m in the densest neighborhoods during the peak of the population and roughness length rising from near-zero to peak at about 0.25 m near the windward edge of the city. Micrometeorology can also be translated into music and art, and can connect people to their microclimates in visceral and intangible ways, requiring no prior knowledge to learn from direct experience, and offering a gateway to conversations about our impacts on the climate system.

Acknowledgements

This project was made possible initially due to a San Francisco State University Office of Research and Sponsored Programs grant and the generous collaboration of burningman.org. Additional micro-meteorological field support was provided by Craig Clements and Jim Pettigrew. We would also like to acknowledge our amazing Camp Antenna community for the logistical support, social energy, artistic creativity, comradery and megaphoning required to turn a micronmeteorological project into a Burning Man theme camp. This is especially the case for Doris Dialogu, without whose leadership the project would surely have failed.

References


Redman, M. 2014. Investigating the Urban Heat Island effect of Black Rock City, Nevada during the Burning Man Festival, 2013. Undergraduate Thesis in B.S. Meteorology, Dept. Earth & Climate Sciences, San Francisco State University, California, USA.


Urban climate studies in Glasgow: Antecedents to future directions

The importance of urban climate knowledge on cool climate cities is gaining attention, thanks largely to awareness of climate change and the generally weak levels of preparedness to deal with such changes, especially in terms of air temperature and thermal comfort. Nevertheless, this is a relatively new phenomenon; after all, urban warming had been seen as a ‘positive’ in cold climates not that long ago (e.g. Chandler, 1965 in London – less heating energy needs, longer growing season, reduced need for snow clearance, etc.). During the last 50 years considerable knowledge on the urban climate of cold climate cities (many of which are mature urban centres) has been accumulated.

The aim of the present article is to highlight recent developments (last 10 years) in the study of urban climate in Glasgow, UK and how this has interfaced with policy developments, especially towards climate change adaptation. We aim to trace the trajectory of our recent efforts towards this and explore the linkages to policy development and action towards adapting to climate change in Glasgow and the surrounding region.

Background and historical developments

One of the earliest descriptions of the Glasgow UHI phenomenon was carried out over 40 years ago (Hartley, 1977). Figure 1 shows the structure of the UHI on a mid-autumn night in 1975.

However, there have been no other published records of Glasgow urban climate studies – until about ten years ago, when we began our collaborations in the study of thermal anomaly and urban thermal comfort with a view to both understanding the nature of the ‘problem’ and the ‘solutions’ and policy implications of the phenomenon.

Nature of Glasgow’s UHI

An initial study was carried out in 2010-11 (Emmanuel and Krüger 2012) investigating changes in air temperature within the urbanized area of Glasgow relative to the surrounding Central Belt Region climate using historical data from several sources: UK Met Office (climate normals and running data for a 50 year-period); MIDAS Surface Weather Stations network of the British Atmospheric Data Centre (BADC); and Weather Underground network. Our results suggested that the urban area superimposes a local warming effect over regional trends. Even though regional trends are accompanied by a similar decrease in heating degree days (HDD) in Glasgow’s urban area over time – with local decrease in HDD possibly due to regional warming, a comparison between climate normals for Glasgow Airport and West of Scotland shows higher temperatures in Glasgow than regional averages. The number of days with night frost in the urban area drops significantly, from around 70 to 36 days per annum.

In a subsequent study (Krüger and Emmanuel, 2013), we evaluated the effect of atmospheric stability on seasonal ambient temperature differences after deploying two Davis VantagePro2 weather stations at an urban site (at Glasgow Caledonian University, GCU) and at a rural setting (Figure 2). In the same study, intra-urban temperature differences were concomitantly monitored with a string of T/RH Tinytag data loggers located across Glasgow on a N-S transect (Figure 3). The purpose was to estimate the effect of background atmospheric on urban-vs-rural (UHI) as well as on intra-urban air temperature differences in order to identify relationships between morphology and local climate. The monitoring period (from late February to early September 2011) was classified in terms of atmospheric
stability classes according to the modified Pasquill-Gifford-Turner (PGT) classification system (Mohan and Siddiqui, 1998). A consistent warming pattern was observed both between the farthest T/RH station and the group mean with noticeable influence of atmospheric conditions, expressed as PGT Day Types, during the observation period (Table 1). The UHI, by its turn, was not particularly affected by the choice of more stable conditions for analysis according to the PGT scheme (Table 2).

Table 1. Maximum air temperature differences (in K) to ‘Group Mean’ for different periods and atmospheric conditions – intra-urban T/RH stations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SUB2</td>
<td>RES1</td>
</tr>
<tr>
<td>All data</td>
<td>-1.5</td>
<td>-0.6</td>
</tr>
<tr>
<td>Cold Period</td>
<td>-1.4</td>
<td>-0.5</td>
</tr>
<tr>
<td>Warm Period</td>
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<td>-0.6</td>
</tr>
<tr>
<td>Day Type I</td>
<td>-2.7</td>
<td>-0.9</td>
</tr>
<tr>
<td>Day Type II</td>
<td>-1.6</td>
<td>-0.7</td>
</tr>
<tr>
<td>Day Type III</td>
<td>-1.4</td>
<td>-0.6</td>
</tr>
<tr>
<td>Unclassified days</td>
<td>-1.4</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

Table 2. Average UHI (ΔT\text{UHI} in K) for different periods and atmospheric conditions

<table>
<thead>
<tr>
<th></th>
<th>daytime (average)</th>
<th>night time (average)</th>
<th>night time (minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All data</td>
<td>1.6</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Cold Period</td>
<td>1.6</td>
<td>2.2</td>
<td>3.2</td>
</tr>
<tr>
<td>Warm Period</td>
<td>1.6</td>
<td>2.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Day Type I</td>
<td>1.6</td>
<td>2.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Day Type II</td>
<td>1.9</td>
<td>2.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Day Type III</td>
<td>1.7</td>
<td>2.6</td>
<td>3.9</td>
</tr>
<tr>
<td>Unclassified days</td>
<td>2.0</td>
<td>1.3</td>
<td>2.9</td>
</tr>
</tbody>
</table>
selected on the basis of SVF with a wide variety of urban shapes (narrow streets, neighbourhood green spaces, urban parks, street canyons and public squares) and compared to a reference urban weather station during a total of twenty three transects during late spring and summer periods. The locations used in this study differed from the ones used before, as they are located in the city core area. The method consisted of diurnal transects, covered on foot or by bicycle following designated routes (eastbound and westbound) as shown in Figure 4.

The urban area wherein traverses took place was selected according to a previous study by Emmanuel and Lonconsole (2015) where authors used the Local Climate Zone ‘LCZ’ classification for Glasgow from LIDAR data available with local authorities in order to identify potential problem areas as regards overheating in summer. According to that study, the city centre area (Glasgow City Centre West and Glasgow City Centre East) was categorized as the LCZ class ‘compact midrise’. Maximum daytime intra-urban temperature differences were found to be strongly correlated with atmospheric stability classes. Furthermore, significant intra-urban differences in air temperature are noticeable in urban canyons (e.g. in E-W street canyons), with a direct correlation to the site’s SVF (or sky openness) and with an indiscernible trend under open-air conditions (Figure 5).

The UHI intensity in Glasgow can reach almost 4°C under certain atmospheric conditions, yet such temperature differences are not solely determined by atmospheric stability classes, i.e. such are not determining factors for explaining local UHI. On the other hand, daytime intra-urban temperature differences tend to be affected by PGT patterns with increasing urban density. Particular Day Types (resulting PGT class for daytime periods) will bring stronger temperature differentiation within urban core locations. By identifying the dominant atmospheric classes in summer for Glasgow as A-B (cf. Figure 5) (Drach et al., 2018), it may be assumed that such conditions favor strong differences in air temperature within urban canyons, impacting to a greater or lesser extent the thermal comfort of pedestrians.

**Thermal comfort in urban Glasgow**

With the aim of understanding the thermal preferences and defining a preliminary outdoor comfort range for Glasgow’s urban population, an extensive series of measurements and surveys were carried out during winter and summer 2011 during 19 monitoring campaigns at six different monitoring points in pedestrian downtown areas (Krüger et al., 2012). For data collection, we used a Davis Vantage Pro2 weather station, equipped with temperature and humidity sensors, cup anemometer with wind vane, silicon pyranometer and globe thermometer.

**Figure 5. Relative variations in air-temperature differences for varying atmospheric conditions – for E-W street canyons (left), and for open-air locations (right).**
Two thermal indices were adopted for comparisons against field data (in this case, thermal sensation votes): the 'Temperature Humidity Sun Wind' (THSW) index, and the Physiological Equivalent Temperature (PET) index (Krüger et al., 2013). The THSW index uses humidity and temperature to calculate an apparent temperature, expressed in °C, incorporating the heating effect of solar radiation and the cooling effect of wind on perceived temperature (Steadman 1984). The PET index, expressed in °C, is defined by Höppe (1999) as the equivalent temperature to the air temperature in which, for a typical internal situation, the thermal balance of the human does not change, considering the same core and skin temperatures as in the original situation. Whereas THSW is a direct output from Davis VantagePro2 weather stations, PET calculations were performed with the RayMan model (Matzarakis et al., 2010).

Correlating binned thermal sensation (TS) data to discrete changes in temperature in the two scales (THSW and PET) allowed us to assess comfort ranges for both indices, with high correlation coefficients between binned TS data and index values (r-squared 0.95 and 0.91, for THSW and PET, respectively) (Figure 6).

The obtained comfort/thermal neutrality ranges for Glasgow are roughly 13-19°C (THSW) and 9-18°C (PET). Thermal discomfort due to cold or heat can be assumed to be THSW or PET values below or above these ranges, respectively. Remarkably, optimal ranges for the PET index in Glasgow are lower than those suggested by literature, which might be related to long-term climate acclimatization of Glaswegians.

The preliminary definition of a comfort zone allowed us to assess the impact of the urban area with respect to thermal comfort/discomfort levels at the reference urban location relative to a rural location (using data from the reference station at GCU and at the stationary weather station at Cochno Farm, cf. Figure 2) (Krüger et al., 2013). THSW data assessed directly from readings of the two Davis stations and post-processed PET data in RayMan for the two locations, expressed as percent variations in thermal comfort/discomfort due to cold and heat yielded statistically significant differences between the rural site and the urban location (p<<0.05) with the urban site benefitting from less cold though with a slight increase in heat stress.

From the outdoor comfort campaigns, an important finding was to obtain a target condition, i.e. to identify optimal exposure conditions for pedestrians which could serve as guidance in urban planning design. The beneficial aspect of having less cold in the city in a high-latitude location such as Glasgow can yet be deceptive. High latitude urban areas such as Glasgow already have a significant cooling load – e.g. Kolokotroni et al. (2007) showed that the urban heat island effect would cause an increase in annual cooling load slightly higher than the annual heating load (25% and 22%, respectively) in London. Climate change might bring greater heat stress and cooling needs in the future.

Mitigation of urban heat island in Glasgow

Emmanuel and Loconsole (2015) explored the role of green infrastructure to mitigate local warming in the Glasgow Clyde Valley (GCV) region, with simulations in ENVI-met considering six scenarios: present (2012) and future (2050) predictions for different percentages of increased green cover relative to a base-case scenario. Based on a LCZ classification of the city region, the study concluded that green infrastructure could play a significant role in mitigating the urban overheating expected under a warming climate in the GCV Region. A green cover increase of approximately 20% over the present level could eliminate a third to a half of the expected extra urban heat island effect in 2050 (Figure 7). This level of increase in green cover could also lead to local reductions in surface temperature by up to 2°C. From the thermal comfort perspective, it was estimated that over half of the street users would consider their experience of the city centre to be thermally acceptable (i.e. with a 'comfort vote' between −1.0 and +1.0 for the PMV index, according to ISO 7730)
for a 20% increase in green cover, even under a warm 2050 scenario (Table 3).

While a 20% increase in green cover in the urban core might appear impractical at first, green infrastructure assessment schema such as the Green Area Ratio (GAR) method currently in use in Berlin and elsewhere may provide a methodology to devise alternative approaches to enhancing green cover in urban areas. We have explored such options for the Glasgow city core (Table 4).

**Policy Implications**

The Adaptation Sub Committee (ASC) of the UK Committee on Climate Change (CCC) in its second synthesis report (ASC, 2017) on Climate Change Risk Assessment, highlighted addressing flood risks and heat-related impacts on health and wellbeing as in urgent need for further action/research in Scotland. In Glasgow itself, the Local Climate Impact profile during the last 40 years (Glasgow City Council, 2016) shows that average rainfall has increased by 21%; maximum temperatures have increased on average by 1.12°C and the number of heat waves is up by 6 days per year.

Our urban climate studies in Glasgow have had considerable traction within the climate change adaptation policy community. In particular, our work in partnership with the Glasgow Clyde Valley Green Network Partnership (GCVGNP) has been influential in pushing the ‘green infrastructure’ agenda as a potential adaptation option for both flood prevention at the regional scale as well as overheating mitigation at local scale (Emmanuel, 2013). We have thus attempted to embed urban climate studies within the wider (and potentially more popular) attempts to adapt to climate change. This might provide a template for engagement with the policy development community, not just in the cold climate regions.

**References**


**Table 3. Changes in Predicted Mean Vote (PMV) due to a 20% increase in green cover in 2050, relative to current conditions, with highlighted comfort range as given in ISO 7730**

<table>
<thead>
<tr>
<th>PMV</th>
<th>Glasgow City Centre – West</th>
<th>Glasgow City Centre – East</th>
<th>Paisley</th>
<th>Clyde Gateway</th>
<th>Wishaw</th>
<th>Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; -2.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-2.0 to -1.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-1.5 to -1.0</td>
<td>0.7%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.0%</td>
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<tr>
<td>-1.0 to -0.5</td>
<td>-</td>
<td>-</td>
<td>7.7%</td>
<td>1.0%</td>
<td>1.4%</td>
<td>8.9%</td>
</tr>
<tr>
<td>-0.5 to 0.0</td>
<td>4.9%</td>
<td>3.6%</td>
<td>31.1%</td>
<td>20.4%</td>
<td>11.9%</td>
<td>19.1%</td>
</tr>
<tr>
<td>0.0 to +0.5</td>
<td>31.8%</td>
<td>35.6%</td>
<td>12.5%</td>
<td>8.4%</td>
<td>9.2%</td>
<td>8.4%</td>
</tr>
<tr>
<td>+0.5 to 1.0</td>
<td>15.8%</td>
<td>15.4%</td>
<td>5.8%</td>
<td>3.9%</td>
<td>2.1%</td>
<td>5.4%</td>
</tr>
<tr>
<td>+1.0 to +1.5</td>
<td>0.6%</td>
<td>2.1%</td>
<td>15.3%</td>
<td>15.3%</td>
<td>9.6%</td>
<td>18.7%</td>
</tr>
<tr>
<td>+1.5 to +2.0</td>
<td>7.0%</td>
<td>6.8%</td>
<td>24.6%</td>
<td>44.2%</td>
<td>57.6%</td>
<td>34.9%</td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>40.0%</td>
<td>36.6%</td>
<td>2.5%</td>
<td>6.8%</td>
<td>8.2%</td>
<td>2.6%</td>
</tr>
</tbody>
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Patricia Drach
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Brazil

Table 4. Alternative approaches to increasing green cover by 20% in Glasgow City Centre

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Permeable vegetated area (m²)</th>
<th>Street trees (Nos.)</th>
<th>Intensive Roof Garden (m²)</th>
<th>Extensive Roof Garden (m²)</th>
<th>Green façade (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A large park only</td>
<td>1,056</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Street trees only</td>
<td>-</td>
<td>528</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50% of additional greenery in street trees, balance intensive roof garden</td>
<td>-</td>
<td>264</td>
<td>755</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50% of additional greenery in street trees, balance extensive roof garden</td>
<td>-</td>
<td>264</td>
<td>-</td>
<td>1,056</td>
<td>-</td>
</tr>
<tr>
<td>Mix of intensive (50%) and extensive (50%) roof garden</td>
<td>-</td>
<td>-</td>
<td>755</td>
<td>1,056</td>
<td>-</td>
</tr>
<tr>
<td>50% of all ‘sun facing’ (i.e. South &amp; West) façade covered in green</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1,268</td>
</tr>
</tbody>
</table>


Glasgow City Council, 2016. Glasgow’s Local Climate Impact Profile, available at: https://www.glasgow.gov.uk/CHttpHandler.ashx?id=7272&p=0


As a woman in science I have become quite used to often being the only woman in a meeting, or attending conferences or workshops where the vast majority of keynote speakers are men. I say I have become used to these situations, but I am never actually comfortable in them. When you are the only woman in the room, it is quite easy to feel like an impostor. And the numbers don’t stack up; women are at parity with men in undergraduate and postgraduate degrees, yet they make up less than a quarter of university professors. Biases against women in science are both implicit and explicit. And we all exhibit biases, regardless of our gender. A recent study found that both men and women faculty ranked a job applicant called “John” more competent, suitable for hire, and offered a higher salary, than when the exact same application was labeled “Jennifer”. Furthermore, women postdoctoral applicants have to publish at least three times as many papers in prestigious journals to be judged as successful as male applicants.

Organizations that are diverse and equitable are often more productive and innovative. Consider the loss of intellectual capacity we experience by not involving women in an equitable way, and by not elevating them to leadership positions.

By Melissa Hart
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Melissa Hart recently embarked on a three-week expedition to Antarctica, culminating her year-long participation in the Homeward Bound Women in STEMM leadership program.

Women in STEMM leadership: lessons from Antarctica

Gender representation by student completions and academic level
All STEMM fields, 2014


So what can we do to redress this gender balance? Women in STEMM leadership programs are one strategy. I have recently completed the Homeward Bound Women in STEMM (science, technology, engineering, mathematics, medicine) leadership program. Homeward Bound has a long-term goal to build and support, over the next 10 years, a global network of 1000 women focusing on the leadership and strategy required to contribute towards a more sustainable future. Each year’s cohort undertakes a year-long program to develop leadership, strategic and communication capabilities, culminating in a 3-week voyage to Antarctica. Antarctica is chosen as the backdrop is it provides a perfect location for an introspective program, does not belong to any one country, and prior to the 1960s many countries did not allow women scientists to travel there. Homeward Bound is creating the largest ever all women expeditions to Antarctica.

I was one of 78 women, from 23 countries, selected via a globally competitive process, to join the program’s 2nd cohort. The women came from all sectors of STEMM, and consisted of one-third early career, one-third mid-career, and one-third senior STEMM professionals.

The program is delivered remotely, via zoom, over 11 months, and then in February, 2018 we met in Ushuaia, Argentina, to board a recommissioned NOAA research vessel on a 3-week expedition to Antarctica. During the voyage we spent half of each day working on the program, and the other half on Antarctic land visits, including visits to five research stations where we learned about the science program and were able to ask questions about leading in such a remote environment.

The Homeward Bound program consists of lectures, personal and leadership development tools, coaching sessions, visibility and science communication training and the opportunity to develop collaborations. We all came out of the program with insight into our individual leadership style and strategies to make it more effective, our own personal visibility goals, and a 100 day strategy plan to put this all in place.

What I believe to be one of the fundamental outcomes of this program is the network of Homeward Bound women now growing globally. This network has now become a brain trust we can all call on at any time for advice, mentoring, or simply sharing of experiences as women working in STEMM. This network has led to new collaborations that have resulted in prizes, grants and publications, and I find myself continuously benefiting from it in my career. I look forward to seeing what a network of 1000 women can achieve at the culmination of the Homeward Bound initiative.

A paper that came out just last month shows that academic societies, like the IAUC, can also play a vital role in supporting women in leadership. The authors found that the societies with more women in leadership positions were those that had a visible statement of equality. They include a gender equity check list that suggests that professional societies should, among others: form a committee dedicated to equity and diversity, provide written expectations for appropriate behavior at society events, track demographic data of society members, and communicate about inclusion, diversity and equity to the membership.

I chair an Equity and Diversity committee within the Australian Meteorological and Oceanographic Society (AMOS) that has made significant developments into our society’s culture around equity. However, I still struggle to find men interested in joining the committee, or being involved in committee events. These are issues that cannot fall wholly on women in leadership within a society; they cannot be seen as simply “women’s issues”, they also require male champions of change.

I invite members of IAUC to consider what equity in STEMM should look like, and encourage urban climate women to consider the Homeward Bound program. I am more than happy to answer any questions about the program or the application process.
Urban climate, urban biometeorology, and science tools for cities at EGU 2018

By Sorin Cheval1,2,3, Matthias Demuzere4, Matei Georgescu5, Hendrik Wouters6
1National Meteorological Administration, Bucharest, Romania (sorin.cheval@icub.unibuc.ro)
2“Henri Coandă” Air Force Academy, Braşov, Romania; 3University of Bucharest, Romania
4Ghent University, Belgium; 5School of Geographical Sciences & Urban Planning, Arizona State University, USA

On 8–13 April 2018, the European Geosciences Union (EGU) General Assembly was held in Vienna, Austria. The well-known yearly event hosted by the capital of Austria gathered geoscientists from all around the world; about 15,000 scientists from 106 different countries registered this year. With the urban environment of increasing scientific concern, one of the EGU sessions was dedicated to “Urban climate, urban biometeorology, and science tools for cities”.

In recent years, this session has been regularly included in EGU’s programme and has attracted broad participation from the scientific community. In 2018, the session featured 18 oral presentations and 31 posters and for the first time, included three oral sessions. The three blocks of oral sessions tackled a variety of subjects aiming to identify and assess key gaps, challenges and solutions for cities located in different geographic environments. The presentations focused on themes such as urban climate modelling at different scales, including biometeorological assessments under climate change scenarios, thermal comfort impacts, urban planning, the role of earth observation products and tools for urban climate services, and numerous public representatives attended the session.

The oral sessions included one invited presentation delivered by Prof. Andreas Matzarakis (– Wetterdienst, Research Centre Human Biometeorology, Freiburg, Germany) entitled “Possibilities and limitations of applying thermal indices and micro-scale bio-climate models in urban environments.”

The poster session equally offered a good opportunity to share knowledge and experience between the academic community and practitioners around the globe. Moreover, the geographic coverage of the contributions (e.g., case studies from cities including Vancouver, Prague, Moscow, Seoul, and multiple cities in India) demonstrated the considerable interest in urban climate and its impact on human comfort in cities worldwide. The vibrant interaction among researchers offered a unique opportunity for dissemination of novel approaches and techniques, opportunities for collaboration among new colleagues, and development of strategic engagement between existing colleagues.

Building on the success of the 2018 session on Urban climate and urban biometeorology at the EGU General Assembly, we are strongly committed to organize this session next year (7–12 April 2019), and we welcome interest from the urban climate community in contributing and sharing your research results at the conference in 2019.
Urban Climate News: A brief review of the last 18 months

Greetings to all, on the eve of ICUC-10 in New York City. A year and a half have passed since my last 18-month review of contributions to the Urban Climate News (previous 18-month reviews can be seen in the June 2009, December 2010, June 2012, December 2013 and June 2015 issues).

During this time I have had the good fortune to work with a newly expanded editorial staff, which includes Paul Alexander (“In the News”), Helen Ward (Features and Urban Projects), Joe McFadden (Conferences), and Matthias Demuzere (Bibliography). I would like to thank each and every one of these dedicated people for their enthusiasm and cooperative spirit, and also to recognize the many other IAUC members who have contributed their time and energy to the newsletter.

A special word of gratitude is due to James Voogt, who is finishing his term as President of the IAUC. Jamie has provided not only a reliable and calm hand at the wheel, but also a clear voice of leadership when the organization’s values of inclusiveness and tolerance needed to be expressed. I’m sure I speak for many in thanking Jamie for his truly collaborative efforts over the last few years, and in welcoming Nigel Tapper as the new President.

Over the course of these last eighteen months, Paul has given us a special series of articles profiling the eleven winners of the C40 Cities Award for addressing climate change in 2016. We have seen how cities are taking the initiative and being recognized for addressing a multiplicity of climate-related issues: Melbourne and Sydney in the realm of Building Energy Efficiency, Portland for Climate Action, Paris for Adaptation Planning and Assessment, Yokohama for Clean Energy, Shenzhen for Finance & Economic Development, Copenhagen for Climate Adaptation Action, Addis Ababa for Urban Transportation, Curitiba for Sustainable Communities, Kolkata for Solid Waste, and Seoul for Social Equity & Climate Change. Nowhere was the intertwining of urbanization and climate illustrated more dramatically then in Houston, where Hurricane Harvey made landfall last August.

Understanding the nature of these urban phenomena, and developing tools to cope with them in the future, is what drives many of us in the IAUC. The published research studies and ongoing projects that have been featured in recent issues of UCN (see Tables below) offer a glimpse of how these efforts are advancing. Thanks again to Helen for identifying these activities and facilitating their publication here, and I invite you to contact her at Helen.Ward@uibk.ac.at if you are interested in sharing your material with the urban climate community.

Another indicator of the vitality of our field is the sheer number of international gatherings devoted to urban climate-related themes. Special reports on recent conferences and announcements of those upcoming are all overseen by Joe (mcfadden@ucsb.edu), and I urge you to let him know about any such events – past or future – that would be of interest to our readers. Likewise, you can add to the ever-growing database of urban climate publications by contacting Matthias (matthias.demuzere@ugent.be), Chair of the (also ever-growing) Bibliography Committee.

For all those attending ICUC10, I wish you an enjoyable time in NYC as well as a stimulating conference – and I look forward to seeing you there!

— David Pearlmutter, Editor

### Feature Articles

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<td>HUMINEX: The HUMan INfluence EXperiment to evaluate the quality of crowdsourced data on urban morphology</td>
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<td>Mitigating urban heat islands: Does research support the needs of policy makers?</td>
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### Author(s)

- Paul Alexander
- Helen Ward
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<td>Soil respiration across the greater Boston area; a substantial source of CO₂ to the atmosphere</td>
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<td>Urban cooling from heat mitigation strategies: Systematic review of the numerical modeling literature</td>
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<td>Urban Climate Summer School (Romania) – Key Outcomes, Lessons Learned and Future Directions</td>
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<td>Insights from more than ten years of CO₂ flux measurements in the city of Basel, Switzerland</td>
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<td>Single-column Urban Boundary Layer Inter-comparison Modelling Experiment (SUBLIME): Call for participation</td>
<td>Gert-Jan Steeneveld et al.</td>
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<td>Crowdsourcing urban air temperatures from citizen weather stations</td>
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<td>Are detailed urban parameter datasets highly relevant for urban climate modelling?</td>
<td>Oscar Brousse et al.</td>
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<td>How high-resolution large-eddy simulation modelling is used to support urban planning in Helsinki, Finland</td>
<td>Mona Kurppa et al.</td>
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<td>Urban climate studies in Glasgow: Antecedents to future directions</td>
<td>Rohinton Emmanuel et al.</td>
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Special Reports in recent issues have highlighted the diversity of international conferences, symposia and other gatherings related to climate and people.
Recent Urban Climate Publications


In this edition is a list of publications that have come out between March and May 2018. 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, Year, Volume, Issue, Pages, Dates, Keywords, URL, and Abstract. Please send the references in a .bib format.

As of this month, Qunshan Zhao from the School of Geographical Sciences & Urban Planning (Arizona State University, USA) joined the BibCom team. Note that we are always looking for (young) researchers to join and contribute to the Committee. If you are interested to join or would like to receive more information, please let me know via the email address below.

Regards,

Matthias Demuzere
Chair IAUC Bibliography Committee
Hydrology & Water Management Lab
University of Ghent, Belgium
matthias.demuzere@ugent.be

The Bibliography Committee


Goulart EV, Coceal O, Belcher SE (2018) Dispersion of a Passive Scalar Within and Above an Urban Street Net-


Saraswati, Sharma SK, Mandal TK (2018) Five-year measurements of ambient ammonia and its relationships with other trace gases at an urban site of Delhi, India. Meteorology and Atmospheric Physics 130:241–257.


Scaramboni C, Crispim CP, Toledo Jr. JC, Campos ML (2018) Investigating hydrogen peroxide in rainwater of...


Wang D, Chen Y, Zhan W (2018) A geometric model to simulate thermal anisotropy over a sparse urban surface


haze episodes at an urban site in Beijing, China. Atmospheric Environment 177:275-282.


Upcoming Conferences...

INTERNATIONAL CONFERENCE ON THE MANAGEMENT OF ENERGY, CLIMATE AND AIR FOR A SUSTAINABLE SOCIETY MECAS2018
Havana, Cuba • July 4-6, 2018
https://mecas2018.com/

10TH INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC10) AND 14TH SYMPOSIUM ON THE URBAN ENVIRONMENT (SUE) OF THE AMERICAN METEOROLOGICAL SOCIETY (AMS)
New York, USA • August 6-10, 2018.
https://www.ametsoc.org/ams/index.cfm/meetings-events/ams-meetings/10th-international-conference-on-urban-climate-14th-symposium-on-the-urban-environment/

EUROPEAN METEOROLOGICAL SOCIETY ANNUAL MEETING: SESSION ON “AIR POLLUTION, WEATHER AND CLIMATE AND THEIR MUTUAL INTERACTIONS FROM LOCAL/URBAN TO GLOBAL SCALES”
Budapest, Hungary • September 3-7, 2018
https://www.ems2018.eu/

SPIE REMOTE SENSING 2018 CONFERENCE ON “REMOTE SENSING TECHNOLOGIES AND APPLICATIONS IN URBAN ENVIRONMENTS”
Berlin, Germany • September 10-13, 2018
https://spie.org/ERS/conferencedetails/remote-sensing-technologies-and-applications-in-urban-environments

THIRD ICOS SCIENCE CONFERENCE: SESSION ON “URBAN GREENHOUSE GAS BUDGET – FROM NOVEL MONITORING NETWORKS TO SOURCE IDENTIFICATION”
Prague, Czech Republic • September 11-13, 2018
https://conference.icos-ri.eu/abstracts/

WORLD FORUM ON URBAN FORESTS: CHANGING THE NATURE OF CITIES
Mantua, Italy • November 28 - December 1, 2018
https://www.wfuf2018.com/

PASSIVE & LOW ENERGY ARCHITECTURE (PLEA 2018): SMART & HEALTHY WITHIN THE 2° LIMIT
Hong Kong, China • December 10-12, 2018
http://www.plea2018.org/

AMERICAN GEOPHYSICAL UNION FALL MEETING SESSION ON “URBAN AREAS AND GLOBAL CHANGE”
Washington, D.C., USA • December 10-14, 2018
https://fallmeeting.agu.org/2018/

Calls for Abstract submissions...

Urban Climate – Special Issue on “Urban Data and Climate Information Services” (deadline 15 July 2018)

Atmosphere – Special Issue on “Urban Climate” (deadline 31 December 2018)
More than 500 paid registrations have been received for ICUC-10 and both conference hotels are fully booked. The organizers anticipate about 600 conference attendees.

The program is now well defined and available from https://ams.confex.com/ams/ICUC10/meetingapp.cgi/
Home/0

Work continues on some details of related events, including special guests. A number of conference related events are taking place in association with ICUC-10.

These include:

- A GOES-R workshop hosted by NOAA with two groups, LST and aerosols.
- An IAUC sponsored Diversity and Equality on Urban Climate event (Monday 6 pm).
- Urban Climate Authors Charrette (Tuesday 6 pm): meet authors of recent books and monographs on urban climate who will be present to meet researchers, answer questions, and sign books.
- A practical workshop, led by Fredrik Lindberg, on the Urban Multi-scale Environmental Predictor (UMEP) Wednesday 1-5 pm. Pre-registration required.


The conference has further leveraged two other related events. The first is a US National Science Foundation workshop on Urban Climate and Resiliency. This workshop will have participants contribute to answering one or more science questions related to Urban Climate and Resiliency, with a one day post-conference workshop to synthesize results followed by a report to the US National Academies. The second is an Urban Design Climate Workshop to be held on 10 and 11 August in New York City by the Urban Climate Change Research Network (UCCRN) of the publication Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network (ARC3.2). The workshop is intended to examine the Sunnyside Yard in the Queens district of New York City, which is under consideration for large-scale development. The analysis is intended to identify microclimatic hot spots and to undertake an evaluation of urban thermal comfort for both present day and 2050 conditions.

The Organizers look forward to greeting you in New York City in August!
ICUC-11 update: The Final Four

In March the IAUC initiated the process of soliciting proposals to host the next International Conference on Urban Climate (ICUC-11). We received a total of 11 expressions of interest which the Board screened with an emphasis on:

- location, including geographic diversity from recent locations
- familiarity of the proposing team with IAUC
- proposed timing

The Board then invited a subset of the proposing teams to submit full proposals by June 15. Four full proposals were received for the following locations (and tentative proposed dates):

- **Beijing, CHINA** (June 2021)
- **Hong Kong, CHINA** (Dec 2021)
- **Sao Paulo, BRAZIL** (July 2021)
- **Sydney AUSTRALIA** (Aug-Sept 2021)

In the coming weeks the IAUC Board will share summary information from each proposal with the entire IAUC membership and solicit the membership’s input through an online preference survey. The proposing teams will be interviewed by the Board during the ICUC-10 meeting in New York in August. It is anticipated that the Board will then announce the selected venue before the end of the year.

— David Sailor, IAUC Secretary