Urban Climate News

Quarterly Newsletter of the IAUC

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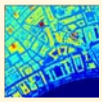
From the IAUC President

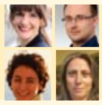
Welcome to the March 2018 edition of the *Urban Climate News.*

Earlier this month I had the privilege of attending the CitiesIPCC conference in Edmonton, Canada. This first of its kind event brought together a wide range of disciplines with interests related to climate change and cities. IAUC members may be interested in the resources available from their website, which include some pre-conference position papers that were intended to help frame the overall conference discussions, as well as links to video recordings of some of the plenary sessions. Members may have also already taken note of the pre-conference commentaries that have been published in *Nature* (1 Mar 2018) and *Nature Climate Change* (March 2018). A longer conference report is available elsewhere in this issue – with thanks to Winston Chow.

I think it is a good advance that the importance of urban areas in all aspects of climate change has been recognized by the IPCC, with an expectation that there will be a greater focus on urban areas in future Assessment Reports (AR), with a Special Report on Cities and Climate Change expected as part of AR7. As a co-convenor of a session, I was also aware that a fairly detailed reporting procedure was required to provide the conference organizers with the summary of relevant key knowledge and recommendations from each session. This will be a key resource in their goal of building a new, jointly created, global research agenda on cities and climate change. I was also pleased to see the participation of a number of IAUC members as session conveners, panelists, poster presenters and speakers. However, I left the conference with some concerns about the appreciation of the state of knowledge that exists within urban climate science as understood by the broader cities and climate change community. This I think provides a challenge for IAUC and our members to continue to advance communication of their results to broader science, policy maker and practitioner communities and to engage with the CitiesIPCC group as its work evolves.

Inside the Spring issue...





And on the topic of change and the future, the Board of the IAUC has now begun its search for a new President and Secretary, as both my term and that of Secretary David Sailor will end this year. Thank you to past-secretary Rohinton Emmanuel for stepping in to lead this process. I hope that I will be able to report the results of the search by the next newsletter (late June 2018) or at least by the time of ICUC-10. Please note also the call for ICUC-11 – expected to be held in 2021 – is now open, as are nominations for the 2018 Luke Howard Award.

As always, thanks to the *UCN* editorial team of David Pearlmutter, Helen Ward, Paul Alexander, Joe McFadden and Matthias Demuzere for all their hard work on this issue!

– James Voogt,
IAUC President

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Cities are tackling climate change: Conclusion

News Editor Paul Alexander presents the final installment in a special series profiling the eleven winners of the ***C40 Cities Award*** *for addressing climate change in 2016*

Category:	**Solid Waste**
Entrants (2016):	• Auckland, New Zealand • Kolkata, India • Milan, Italy
Winning City:	**Kolkata** *Kolkata solid waste management improvement project (KSWMIP)* https://www.jica.go.jp/english/

A dog standing atop the Dhapa landfill, which receives a large proportion of Kolkata's domestic waste

When researching a complex topic (such as urban areas and their climate) it is often advantageous to adopt a systems approach: breaking down the topic into a series of inputs, processes and outputs. Consider how we apply this to a topic like the surface energy budget: the input is net radiation, the bio-physical processes between the surface and overlying atmosphere produces outputs, namely sensible heating, latent heating and ground heat storage. When we consider the expanded urban surface energy budget our community recognises that humans also provide an input of energy to this system. However, in studying the urban climate, are we ultimately neglecting the central role humans really play in this system? Consider the non-radiative inputs to urban areas; solid materials, water and fuel – these are almost entirely demand driven. Humans are also central to the processes with respect to these inputs; we can think of these processes largely in terms of consumption: consuming fuel generates waste heat, particulates and moisture, consuming food produces effluence and waste materials (non-organic packaging for example). It is convenient to assume these outputs are simply removed from the urban area and therefore not included in our systems approach, but is this a safe assumption? The outputs of the human consumption system are staggering, and it must be stated in no uncertain terms that urban solid waste management is an essential component of the overall urban system and is critical for ensuring the protection of the environment and health of citizens.

The Kolkata solid waste management improvement project (KSWMIP) was the C40 winner for solid waste in 2016. Kolkata is truly a megacity – the urban area has a population of more than 4.5 million people, and if you include the wider region and suburbs, this is home to about 14 million people.

Raising public awareness of KSWMIP by distribution of literature

Imagine every person throws away 1 disposable coffee cup every day; now imagine you are tasked with coordinating the collection and disposal of 14 million coffee cups and lids, every day. The population isn't producing just 1 item of solid waste per day, but in terms of overall weight, this imagination exercise isn't far off – about 154 tonnes every day. The urban solid wastes of Indian cities have low calorific value and high moisture content, as most of the domestic waste is comprised of non-combustible materials and hence it is unsuitable for thermal technologies. That leaves really one option: dump it. Prior to the KSWMIP, waste was piled up to 15 meters (50ft) high at dumping sites, polluting land, water and air. Illegal waste dumping in the Ganga River had resulted in the extinction of several hundred aquatic animals and insects, damaging biodiversity.

There are two broad components of KSWMIP, firstly, education: this is about targeted adoption and promotion of the 3R's (Reduce, Reuse, Recycle) by introducing a curriculum in schools and carrying out public awareness campaigns. This results in most waste being separated at source. Secondly, engineering: further waste segregation occurs at purpose-built transfer stations. This is then transferred to newly engineered sanitary landfill sites or one of five newly built compositing plants. Municipalities can earn revenue from selling the compost produced at these plants. A municipality of 10km^2 can produce more than 25 tonnes of compost a day, which is sold for $41 per tonne and can thus generate around $1000 per day. Recycling and composting rates have dramatically increased since the launch of KSWMIP. Following the public awareness campaign and investment in new equipment, 60-80% of recyclables, compost and solid waste are now separated at homes and offices. The compositing and landfill sites are not yet operating at full capacity, so the real potential of KSWMIP to handle the outputs of Kolkata's consumption remains to be seen.

A city worker collects refuse.

Category: **Social Equity & Climate Change**

Entrants (2016):
- New York City, USA
- Portland, USA
- Seoul, South Korea

Winning City: **Seoul**
Seoul's Energy Welfare Public Private Partnership Program
https://seoulsolution.kr/en/content/public-private-joint-energy-welfare-project

Photovoltaic panels installed on residential roofs

If there is one thing the urban climate community can contribute in a significant way to wider society, it's solutions. While we are already providing greater insights into the challenges that face urban areas, from excess heat, reduced ventilation, poorer air quality and exposure to pluvial and coastal flooding, it is paramount we present these challenges along with workable solutions, paying particular attention to the most vulnerable members of the urban population.

It has been recognised for many years that climate change does not impact all people equally; similarly during extreme events within the urban climate, it is often socially and economically disadvantaged communities which suffer the greatest impacts. The C40 award in Social Equity is presented to cities which develop climate change actions sensitive to the inequality amongst their populations. The winner of the award in 2016 was Seoul, which since 2015 has been applying sensible solutions to address climate change and is focusing these actions on the most disadvantaged members of the 10 million strong urban population. The Energy Welfare Public Private Partnership Programme (SPPP) aims to contribute to the city's targets on greenhouse gas (GHG) emissions reduction while simultaneously reducing energy consumption and spending for low-income families. Launched in 2015, SPPP financed energy retrofits for 1,295 households and a further 1,050 households in 2016.

In collaboration with business and civic groups, 2,400 conventional lightbulbs in low-income houses, markets and child care centres, were replaced with LED bulbs. The city government installed approximately 1,600 micro-photovoltaic (PV) panels at public apartments and low-income households in underdeveloped communities. It also provided for 10,000 sets of winter-use long underwear, 10,000 sets of summer underwear, and 200 insulation tents as part of its efforts to reduce climate risks facing the poor. This isn't just a case of throwing money at a problem, as the energy savings which would have been paid out through social benefits are then reinvested to continue the cycle of retrofitting homes of low-income families. The savings in 2015, estimated to have been close to $178,000, are returned to the Seoul Energy Welfare Civic Fund for expansion of its energy-welfare programmes.


Energy efficient lights installed in homes of the most vulnerable

The fund has also been bolstered by a further $500,810 of monetary and in-kind contributions from 34 businesses and 1,800 citizens across the city. SPPP goes beyond simply retrofitting homes and providing clothing, and has also recruited a total of 180 energy planners and energy social workers who were underemployed, and job seekers have been trained (110 in 2015, 70 in 2016): these individuals are currently conducting inspections of energy usage and the living environments of approximately 1,300 low-income households and local children's welfare centers that are in dire need of energy welfare. Energy-vulnerable individuals continue to contribute to SPPP energy welfare projects in other ways too, providing energy conservation consulting services and various forms of housing repairs/construction to low-income households (e.g. windshield, insulation, Cool Roof). Overall, SPPP is seeking to reduce climate risks threatening low-income families through implementation of the most effective and efficient energy welfare policies. Seoul's efforts are expected to protect the poorest residents from the effects of climate change and lead to a fairer and more sustainable society. Installation of solar PV panels and deployment of LED bulbs at houses will help reduce the energy spending for low-income families. By engaging potential beneficiaries of support, Seoul seeks to reap co-benefits from income growth of the participating low-income families and job creation. Furthermore, the city seeks to improve social equality by reinvesting profits earned from its energy-welfare projects into additional efforts to support the energy poor. Energy savings that are reinvested to help more people and achieve yet more savings – an elegant and equitable solution.

WMO report: 2017 is set to be in top three hottest years

WMO report highlights impacts on human safety, well-being and environment

November 2017 — It is very likely that 2017 will be one of the three hottest years on record, with many high-impact events including catastrophic hurricanes and floods, debilitating heatwaves and drought. Long-term indicators of climate change such as increasing carbon dioxide concentrations, sea level rise and ocean acidification continue unabated. Arctic sea ice coverage remains below average and previously stable Antarctic sea ice extent was at or near a record low.

The World Meteorological Organization's provisional Statement on the State of the Climate says the average global temperature from January to September 2017 was approximately 1.1°C above the pre-industrial era. As a result of a powerful El Niño, 2016 is likely to remain the warmest year on record, with 2017 and 2015 being second and/or third. 2013-2017 is set to be the warmest five-year period on record.

The WMO statement – which covers January to September – was released on the opening day of the United Nations climate change conference in Bonn. It includes information submitted by a wide range of UN agencies on human, socio-economic and environmental impacts as part of a drive to provide a more comprehensive, UN-wide policy brief for decision makers on the interplay between weather, climate and water and the UN global goals.

"The past three years have all been in the top three years in terms of temperature records. This is part of a long term warming trend," said WMO Secretary-General Petteri Taalas. "We have witnessed extraordinary weather, including temperatures topping 50 degrees Celsius in Asia, record-breaking hurricanes in rapid succession in the Caribbean and Atlantic reaching as far as Ireland, devastating monsoon flooding affecting many millions of people and a relentless drought in East Africa.

"Many of these events – and detailed scientific studies will determine exactly how many – bear the tell-tale sign of climate change caused by increased greenhouse gas concentrations from human activities," he said.

Patricia Espinosa, Executive Secretary of UN Climate Change which is hosting the Bonn conference, said: "These findings underline the rising risks to people, economies and the very fabric of life on Earth if we fail to get on track with the aims and ambitions of the Paris Agreement".

"There is unprecedented and very welcome momentum among governments, but also cities, states, territories, regions, business and civil society. Bonn 2017 needs to be the launch pad towards the next, higher level of ambition by all nations and all sectors of society as we look to de-risk

Source: http://www.un.org

the future and maximize the opportunities from a fresh, forward-looking and sustainable development path, "she added.

Extreme events affect the food security of millions of people, especially the most vulnerable. A review of the Food and Agriculture Organisation (FAO) found that, in developing countries, agriculture (crops, livestock, fisheries, aquaculture and forestry) accounted for 26% of all the damage and loss associated with medium to large-scale storms, floods and drought.

According to the World Health Organisation (WHO), the global health impacts of heatwaves depend not only on the overall warming trend, but on how heatwaves are distributed across where people live. Recent research shows that the overall risk of heat-related illness or death has climbed steadily since 1980, with around 30% of the world's population now living in climatic conditions that deliver prolonged extreme heatwaves. Between 2000 and 2016, the number of vulnerable people exposed to heatwave events has increased by approximately 125 million.

In 2016, 23.5 million people were displaced during weather-related disasters. Consistent with previous years, the majority of these internal displacements were associated with floods or storms and occurred in the Asia-Pacific region. In Somalia, more than 760 000 internal displacements have been reported, according to the UN High Commissioner for Refugees and International Organisation for Migration (IOM)

The latest International Monetary Fund (IMF) World Economic Outlook indicates that adverse consequences are concentrated in countries with relatively hot climates and which are home to close to 60% of current global population.

Selected Highlights

Global temperatures in 2017: Global mean temperature for the period January to September 2017 was 0.47°±0.08°C warmer than the 1981-2010 average (estimated at 14.31°C). This represents an approximately 1.1°C increase in temperature since the pre-industrial period. Parts of southern Europe, including Italy, North Africa, parts of east and southern Africa and the Asian part of the Russian Federation were record warm and China was the equal warmest. The northwestern USA and western Canada were cooler than the 1981-2010 average.

Temperatures in 2016 and, to an extent, 2015, were boosted by an exceptionally strong El Niño. 2017 is set to be the warmest year on record without an El Niño influence. The five-year average 2013-2017 is provisionally 0.40°C warmer than the 1981-2010 average and approximately 1.03°C above the pre-industrial period and is likely to be the hottest on record.

The WMO statement is based on five independently maintained global temperature data sets. WMO now uses 1981-2010 instead of the previous 1961-1990 baseline as it is more representative of current climatic conditions and allows for more consistent reporting of information from satellite and reanalysis systems (some of which do not extend back to 1960) alongside more traditional data sets based on surface-observations. The change in the baselines has no influence on trend analysis.

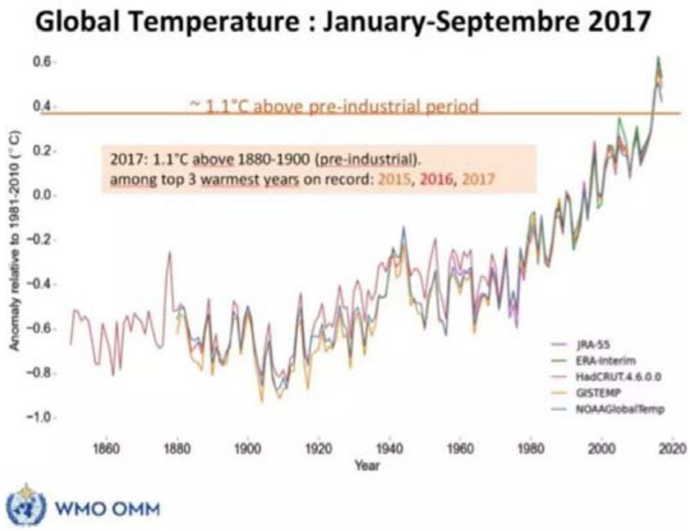
Precipitation: Southern South America (particularly in Argentina), western China, and parts of southeast Asia were wetter than average. January to September was the wettest on record for the contiguous United States. Rainfall was generally close to average in Brazil, and near to above average in northwest South America and Central America, easing droughts associated with the 2015-16 El Niño. The 2017 rainy season saw above-average rainfall over many parts of the Sahel, with flooding in some regions (especially in Niger).

All-India rainfall for the 2017 monsoon season (June to September) was 5% below average. However, above-average rainfall in the northeast, and adjacent countries led to significant flooding.

The Canadian Prairies, the Mediterranean region, Somalia, Mongolia, Gabon and southwestern South Africa all received lower rainfall than average. Italy had its driest January to September on record.

Ice and snow: Arctic sea-ice extent was well below average throughout 2017 and was at record-low levels for the first four months of the year, according to the National Snow and Ice Data Center and the Copernicus Climate Change Service. The Arctic annual maximum extent in early March was among the five lowest in the 1979-2017 satellite record, and according to the NSIDC's data was record low. The five lowest maximum extents have occurred since 2006.

A strong and persistent low pressure system over the central Arctic helped to inhibit ice loss during the summer months. The Arctic sea ice extent minimum in mid-September was 25-31% below the 1981-2010 average, and among



Source: **http://www.un.org**

the eight smallest minimum extents on record. The ten smallest minimum extents have all occurred since 2007.

Antarctic sea ice extent was also well below average. The annual minimum extent in early March was record low, and the annual maximum extent in mid-October was at or near record low levels. Sea ice conditions in the Antarctic have been highly variable over the past several years with the record large sea ice extents occurring as recently as 2015.

Northern Hemisphere snow cover extent was 10.54 million square km, near the median value in the 1967-2017 satellite record.

The Greenland ice sheet saw an increase of more than 40 billion tons of ice due to above-average snowfall and a short melt season. Despite the gain in overall ice mass this year, it is only a small departure from the declining trend, with the Greenland ice sheet having lost approximately 3,600 billion tons of ice mass since 2002.

Sea level: The global mean sea level (GMSL) is one of the best climate change indicators. Global mean sea level has been relatively stable in 2017 to date, similar to levels first reached in late 2015. This is because the temporary influence of the 2015-16 El Niño (during which GMSL peaked in early 2016 at around 10 millimeters above the 2004-2015 trend) continues to unwind and GMSL is reverting to values closer to the long-term trend. Preliminary data indicate that a rise in GMSL may have started to resume from July-August 2017 onwards.

Ocean Heat: Global sea surface temperatures are on track to be among the three highest on record. Global ocean heat content in 2017 to date has been at or near record high levels. Elevated tropical sea surface temperatures which contribute to coral bleaching were not as widespread as during the 2015-16 El Niño. But some significant coral bleaching did still occur, including Australia's Great Barrier Reef. UNESCO reported in June that all but three of the 29 coral reefs with World Heritage listing had experienced temperatures consistent with bleaching at some point in the 2014-2017 period.

Ocean Acidification: According to the Intergovernmental

Oceanographic Commission of UNESCO the ocean absorbs up to 30% of the annual emissions of anthropogenic CO_2 in the atmosphere, helping to alleviate the impacts of climate change on the planet. However, this comes at a steep ecological cost, as the absorbed CO_2 changes acidity levels in the ocean. Since records at Aloha station (north of Hawaii) began in the late 1980s, seawater pH has progressively fallen, from values above 8.10 in the early 1980s to between 8.04 and 8.09 in the last five years.

Ocean acidification is directly influencing the health of coral reefs and the survival and calcification of several key organisms. These have cascading effects within the food web and impact aquaculture and coastal economies.

Greenhouse gases: The rate of increase in CO_2 from 2015 to 2016 was the highest on record, 3.3 parts per million/year, reaching 403.3 parts per million. Global average figures for 2017 will not be available until late 2018. Real-time data from a number of specific locations indicate that levels of CO_2, methane and nitrous oxide continued to increase in 2017.

Tropical cyclones: The North Atlantic had a very active season. The Accumulated Cyclone Energy (ACE) index, a measure of the aggregate intensity and duration of cyclones, had its highest monthly value on record in September.

Three major and high-impact hurricanes occurred in the North Atlantic in rapid succession, with Harvey in August followed by Irma and Maria in September. Harvey made landfall in Texas as a category 4 system and remained near the coast for several days, producing extreme rainfall and flooding. Provisional seven-day rainfall totals reached as high as 1539 mm at a gauge near Nederland, Texas, the largest ever recorded for a single event in the mainland United States.

It was the first time two Category 4 hurricanes (Harvey and Irma) made landfall in the same year in the USA. Irma had winds of 300 km/h for 37 hours – the longest on the satellite record at that intensity and spent three consecutive days as a Category 5 hurricane, also the longest on record. Like Irma, Maria also reached category 5 intensity and caused major destruction on a number of Caribbean islands. In mid-October, Ophelia reached major hurricane (Category 3) status more than 1 000 kilometers further northeast than any previous North Atlantic hurricane. It caused substantial damage in Ireland, whilst winds associated with its circulation contributed to severe wildfires in Portugal and northwest Spain.

The WMO Expert Team on Climate Impacts on Tropical Cyclones found that, whilst there is no clear evidence that climate change is making the occurrence of slow-moving, land-falling hurricanes such as Harvey more or less frequent, it is likely that human-induced climate change makes rainfall rates more intense, and that ongoing sea-level rise exacerbates storm surge impacts.

Flooding: Exceptionally heavy rain triggered a landslide in Freetown, Sierra Leone in August, killing more than 500 people. Freetown received 1459.2 mm of rain in two weeks, about four times higher than average. Heavy rainfall contributed to a landslide in Mocoa, southern Colombia, in April, with at least 273 deaths reported.

Source: http://www.un.org

Many parts of the Indian subcontinent were affected by monsoonal flooding, despite overall seasonal rainfall being near average. The most serious flooding occurred in mid-August in eastern Nepal, northern Bangladesh and nearby northern India. Mawsynram (India) received more than 1 400 mm from 9 to 12 August. Rangpur (Bangladesh) received a month's worth of rain (360 mm) on 11-12 August. More than 1 200 deaths were reported in India, Bangladesh and Nepal, whilst more than 40 million people were displaced or otherwise affected. The World Health Organization indicated that in Bangladesh alone, more than 13 000 cases of waterborne diseases and respiratory infections were reported during three weeks in August, whilst extensive damage was reported to public health facilities in Nepal.

Flooding affected many parts of Peru in March, killing 75 people and making 70,000 homeless. The Food and Agriculture Organization reported that there were significant crop production losses, particularly maize. Flooding of this type typically affects Peru during the late phase of El Niño events. Whilst there was no Pacific-wide El Niño during 2017, sea surface temperatures near the Peruvian coast in March were 2°C or more above average and similar to El Niño values.

Major flooding occurred mid-year in parts of southern China, especially within the Yangtze River basin. Peak totals from 29 June to 2 July topped 250 mm. Fifty-six deaths were reported and economic losses were estimated at more than US$ 5 billion.

Heavy rain affected the western United States in January and February causing substantial flooding, numerous landslides and the evacuation of tens of thousands of people. It was the wettest winter on record for Nevada, and the second-wettest for California.

Drought: Parts of east Africa continued to be seriously affected by drought. Following well-below-average rainfall in 2016, the 2017 "long rains" season (March to May) was also dry in many parts of Somalia, the northern half of Kenya, and southeastern Ethiopia.

FAO reported that in Somalia, as of June 2017, more than half of the cropland was affected by drought, with herds reduced by 40-60% since December 2016. WFP estimates that the number of people on the brink of famine in Somalia has doubled to 800,000 since February 2017, with half the country needing assistance. WFP has confirmed that more than 11 million people are experiencing severe food insecurity in Somalia, Ethiopia and Kenya.

From November 2016 to mid-June 2017, more than 760,000 drought-related internal displacements in Somalia were recorded by the Protection and Return Monitoring Network (PRMN), a United Nations High Commissioner for Refugees (UNHCR) led project.

Kenya declared the 2017 drought a national disaster. Nairobi faced water shortages that compelled city authorities to ration water, whilst cereal prices rose and GDP figures were hit.

An above-average wet summer season eased drought conditions in southern Africa. But localized drought intensified in the Cape Province.

Heavy winter rains in early 2017 eased long-term drought conditions in California, but resulted in some flooding, and contributed to vegetation growth which may have influenced the severity of wildfires later in the year.

Many parts of the Mediterranean experienced dry conditions. The most severe drought was in Italy, hitting agricultural production and causing a 62% drop in olive oil production compared to 2016. Rainfall averaged over Italy for January-August 2017 was 36% below average. It was also Italy's hottest January-August on record, with temperatures 1.31°C above the 1981-2010 average. Other dry areas included many parts of Spain and Portugal.

The Democratic People's Republic of Korea was affected by below-average rains, impacting key staple crops such as paddy and maize. In the Republic of Korea, rainfall from January to June was 51% below average, the lowest since national records began in 1973.

Major heatwaves: An extreme heatwave affected parts of South America in January. In Chile, numerous locations had their highest temperature on record, including Santiago (37.4°C). In Argentina, the temperature reached 43.5°C on 27 January at Puerto Madryn, the highest ever recorded so far south (43°S) anywhere in the world.

Much of eastern Australia experienced extreme heat in January and February, peaking on 11-12 February when temperatures reached 47°C.

Exceptional heat affected parts of southwest Asia in late May. On 28 May, temperatures reached 54.0°C in Turbat, in the far west of Pakistan near the Iranian border, and also exceeded 50°C in Iran and Oman. A temperature of 53.7°C was recorded at Ahwaz, Iran on 29 June, and Bahrain experienced its hottest August on record.

The Chinese city of Shanghai and the Hong Kong Observatory reported new records of 40.9°C and 36.6 °C during summer.

In the Mediterranean, Cordoba in southern Spain experienced 46.9°C on 12 July and Granada 45.7°C on 13 July. An extensive heatwave in early August led to temperature records in northern and central Italy, Croatia and southern France.

California had its hottest summer on record and extreme heat affected other western states. This culminated in a major heatwave at the end of August and early September, which included a record high temperature (41.1°C) at San Francisco.

Wildfires: Extreme heat and drought contributed to many destructive wildfires.

Chile had the most significant forest fires in its history during the 2016-2017 summer, after exceptionally dry conditions during 2016 followed by extreme heat in December and January.

11 deaths were reported, and a total of 614 000 hectares of forest were burnt, easily the highest seasonal total on record and eight times the long-term average. There were also significant fires during the 2016-2017 Southern Hemisphere summer in various parts of eastern Australia and in the Christchurch region of New Zealand, whilst the southern South African town of Knysna was badly affected by fire in June.

It was a very active fire season in the Mediterranean. The worst single incident occurred in central Portugal in June, with 64 deaths. There were further major fire outbreaks in Portugal and northwestern Spain in mid-October, exacerbated by strong winds associated with Hurricane Ophelia. Other significant fires affected countries including Croatia, Italy and France.

The area burned in the contiguous United States from January to 19 October was 46% above the 2007-2016 average. The area burned in the western provinces of Canada was about eight times the 2006-2015 seasonal average and contributed to heavy smoke pollution. A wet winter, which allowed the heavy growth of ground vegetation, followed by a dry and hot summer, provided ideal conditions for high-intensity fires in northern California in early October. At least 41 deaths were reported, the worst loss of life in a wildfire in the United States since 1918.

Other noteworthy events: Severe cold and snow affected parts of Argentina in July. After heavy snow had fallen the previous day, the temperature reached −25.4°C in Bariloche on 16 July, 4.3°C below the previous lowest temperature on record there. Other regions where record low temperatures occurred in 2017 included some locations in inland southeastern Australia in early July, where Canberra had its lowest temperature (−8.7°C) since 1971, and the Gulf region in the Middle East in early February.

The United States had its most active tornado season since 2011, with a preliminary total of 1,321 tornadoes in the January to August period, including the second-most active January on record.

The World Meteorological Organization is the United Nations System's authoritative voice on Weather, Climate and Water. *Website:* public.wmo.int

Source: http://www.un.org/sustainabledevelopment/blog/2017/11/wmo-statement-on-state-of-climate-in-2017/

Cities emit 60% more carbon than previously thought

A new analysis finds that city planners have been undercounting greenhouse gas emissions from a key contributor

March 2018 — The carbon footprint of some of the world's biggest cities is 60 percent larger than previously estimated when all the products and services a city consumes are included, according to a new analysis.

The report was released Tuesday at the IPCC Cities and Climate Change Science Conference in Edmonton, Canada, and estimated the carbon emissions for the food, clothing, electronics, air travel, construction materials, and so on consumed by residents but produced outside city limits.

The world's cities emit 70 percent of the world's carbon dioxide – and that's likely higher when consumption emissions are included, says report author Michael Doust, program director at C40 Cities, a network of the world's cities committed to addressing climate change.

"We're missing the other side of the coin if we only measure emissions involved in the production of food, energy, or other products and services," Doust said in an interview in Edmonton. "Knowing what the consumption emissions are and where allows cities and residents to make better decisions on how to reduce their carbon emissions."

Wealthy "consumer cities" such as London, Paris, New York, Toronto, or Sydney that no longer have large industrial sectors have significantly reduced their local emissions. However, when the emissions associated with their consumption of goods and services are included, these cities' emissions have grown substantially and are among the highest in the world on a per person basis, the report says. Meanwhile, "producer" cities in India, Pakistan, or Bangladesh generate lots of industrial pollution and carbon emissions in the manufacture of products that will be sold and consumed in Europe and North America.

The report, Consumption-based GHG emissions of C40 cities, examined the greenhouse gas emissions associated with goods and services consumed by residents of 79 cites in the C40 network, including food, clothing, electronic equipment, air travel, delivery trucks, and construction industries.

"We're still going in the wrong direction on climate change," said Mark Watts, executive director of C40 Cities. Global carbon emissions have increased 60 percent since the international 1997 Kyoto agreement to reduce emissions. "Using more renewable energy and mass transit won't be enough to reverse this," said Watts. "We have to reduce our consumption."

"This new research will help city policy makers to better understand the true impact of their city on global climate change, and so play an ever bigger leadership role in delivering climate action," he added. (Read: Has the U.S. really reached an energy tipping point?)

The greenery atop Chicago City Hall's roof lowers its summer temperature. *Source:* nationalgeographic.com

Outsourcing pollution?

"What we buy must be part of our efforts to reduce our emissions. We can't just outsource them to other regions," said Don Iveson, the mayor of Edmonton. Iveson said consumption-based accounting is key to knowing what a city's true carbon footprint is. "Smarter purchasing, buying local, and reducing waste are part of what can be done to reduce consumption emissions."

Matt Gray, the chief of sustainability at the city of Cleveland, Ohio, says he welcomes this new approach. By the old method of accounting, manufacturing cities like Cleveland often rank poorly in current measures of sustainability, he notes. Yet cities with service-based economies that consume the things Cleveland makes rank better. Resource consumption was not a factor in last year's U.S. Cities Sustainable Development Goals Index, which put Cleveland at the bottom. Yet the fact that Cleveland is widely considered a national leader in local food production wasn't a factor in the index, Gray said.

In working on this new accounting of consumption emissions, the city of Paris is targeting its tourist promotions to countries where travelers can visit by train, in an effort to reduce emissions from air travel. It's also encouraging residents to change their diets from carbon-emission-heavy meats to vegetarian fare. Stockholm has asked all of its developers to estimate their embodied emissions in construction materials. Simply looking at the data has already led to decisions to use materials with lower emissions, said Doust. And it is helped in city decisions about retrofitting old buildings or building new ones.

What this report shows is cities have an even bigger opportunity to reduce global emissions if they address consumption, he said. — *Stephen Leahy, National Geographic*

Source: https://news.nationalgeographic.com/2018/03/city-consumption-greenhouse-gases-carbon-c40-spd/

The cities leading the transition to renewables

More than 100 cities worldwide get at least 70 percent of their electricity from renewable sources, according to a new initiative. How did they manage and what can we learn from them?

March 2018 — Cities are responsible for 70 percent of manmade CO_2 emissions, according to the International Renewable Energy Agency. Cars, heating, cooling and lighting systems work round the clock, consuming energy and pumping out emissions.

But more and more cities are aiming to source a growing share of that energy from renewables, to become more sustainable and, ultimately, combat climate change.

Around the world, 570 cities have reported their achievements to non-profit group CDP. CDP says over 100 of them get least 70 percent of their electricity from renewable sources, and more than 40 already have a 100-percent renewable power supply.

That might sound impressive. But, electricity isn't everything — cities also consume huge amounts of energy from heating and transport, for example.

Moreover, "renewable" doesn't always mean environmentally sound. Most of the 40 high achievers get their electricity from hydropower plants, which are controversial due to the environmental impacts of dams, and fears that hydropower generation is being hit by climate change.

Renewable cities, key for climate

Half the world's human population lives in cities, and at least 90 percent of people in urban areas live with air quality that falls short of World Health Organization standards.

There's clearly much to be done to reduce urban toll on human and planetary health. But CDP says the data cities have submitted show they're making a start.

"Cities have high ambitions and are taking big steps," Kyra Appleby, director of cities at CDP, told DW.

More than 80 cities and towns in the United Kingdom have pledged to go 100-percent renewable by 2050 as part of UK100, a local government leaders' network.

Reykjavik already gets its electricity and heat from geothermal and hydropower; Basel, Switzerland, gets all its electricity from a 100-renewable city-owned supplier.

Many other European cities are moving towards renewables, not only for electricity but also for heating and transport, Eric Woods, research director with Navigant Research, a green energy tech consultancy, told DW.

Falling green power prices are helping drive this transition. In 2017, unsubsidized renewables were the cheapest source of electricity in 30 countries, and renewable energy is predicted to become far cheaper than energy from fossil fuels by 2020.

Source: **http://www.dw.com/en/the-cities-leading-the-transition-to-renewables/a-42850621**

A US awakening

Despite US President Donald Trump's resistance to the energy transition — or perhaps, in part, because of it — US cities are redoubling their efforts, too.

Across the country, 58 cities have committed to going 100-percent renewable. Of these, 46, including big cities like Atlanta and San Diego, only pledged after Trump's election.

The Global Covenant of Mayors for Climate and Energy has also been a major push for local urban energy transitions, seeing more than 7,000 cities and local governments around the world agree to act on climate change.

Three US cities, including Seattle, get at least 70 percent of their electricity from renewable sources — although again, hydropower is the main one.

Burlington, Vermont, gets all its electricity from a mix of biomass, hydro, solar and wind power, CDP data shows, and according to the Sierra Club, it's not alone. Aspen (Colorado), Greensburg (Kansas), Rock Port (Missouri) and Kodiak Island (Alaska) may be small, but they too have completely given up fossil-fueled electricity.

Lessons to learn

The road to renewables needs adequate governance. Some cities — for example those that own their own municipal utilities, like Basel and Copenhagen — have more power over where they get their energy from.

"Cities need more control over their energy production and stronger support for local generation," Woods said. Local authorities are often more active than national ones, but they are also limited by national energy policy.

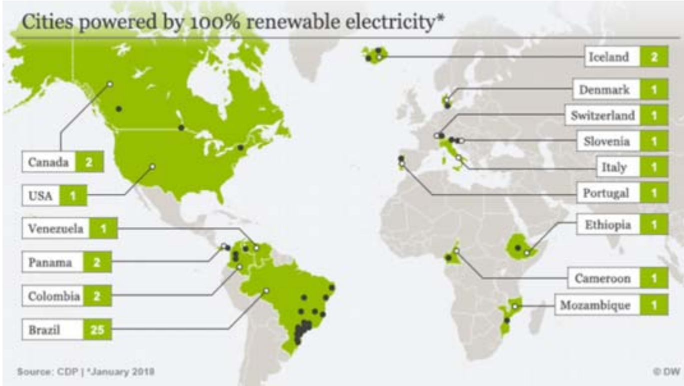
Different cities have different resources available to them. In Geneva, the city's lake is used to cool and heat around 400 buildings, including the United Nations' headquarters, Alix Bolle, EU affairs manager with Energy Cities told DW.

But while not every 100-percent renewable city will look the same, their localized transitions are a chance to try out different solutions, and learn from each other's experience.

Initiatives like the UK100 and Renewables Networking Platform , promoted by the European Forum for Renewable Energy Sources, encourage such exchange.

"Cities are very much willing to learn from each other and replicate solutions or ways of overcoming risks," Bolle said. It's also important that the energy transition is an inclusive process, the Intergovernmental Panel on Climate Change recently stressed, bringing the public and local industry into decision-making to ensure everyone does their bit.

Carina Borgström-Hansson, responsible for WWF's One Planet City Challenge, told DW that involving the local private sector means the energy transition can stimulate entrepreneurship and job creation. She points to Vancouver, Canada, which she says included local businesses in a strategy that has seen the city achieve a



Source: **http://www.dw.com/en/the-cities-leading-the-transition-to-renewables/a-42850621**

98-percent renewable electricity supply.

Reshaping the energy system obviously involves serious investment in infrastructure. But there are also simple things we can all do to decarbonize our cities.

Electrification of the transport system is very important, Borgström-Hansson said, but we can all make an effort to take more journeys by bike or foot.

Source: http://www.dw.com/en/the-cities-leading-the-transition-to-renewables/a-42850621

Copenhagen, Denmark

Reykjavik, Iceland

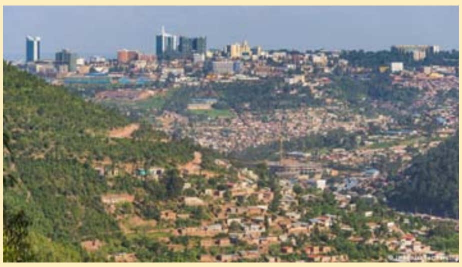
Curitiba, Brazil

San Francisco, United States

The "World's Greenest Cities" (for more details see: http://www.dw.com)

Frankfurt, Germany

Vancouver, Canada



Kigali, Rwanda

Ljubljana, Slovenia

Turning cities into sponges: How Chinese ancient wisdom is taking on climate change

Landscape architect is making 'friends with water' to mitigate extreme weather events in modern metropolises

March 2018 — How does a city cope with extreme weather? These days, urban planning that doesn't factor in some sort of catastrophic weather event is like trying to build something in a fictional utopia. For Kongjian Yu, one of the world's leading landscape architects, the answer to coping with extreme weather events actually lies in the past.

Yu is the founder and dean of the school of landscape architecture at Peking University, founding director of architectural firm Turenscape, and famous for being the man who reintroduced ancient Chinese water systems to modern design. In the process he has transformed some of China's most industrialised cities into standard bearers of green architecture.

Yu's designs aim to build resilience in cities faced with rising sea levels, droughts, floods and so-called "once in a lifetime" storms. At 53, he is best known for his "sponge cities", which use soft material and terraces to capture water which can then be extracted for use, rather than the usual concrete and steel materials which do not absorb water.

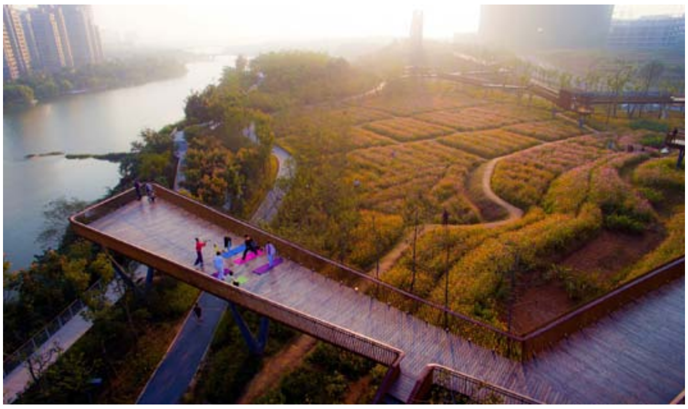
European methods of designing cities involve drainage pipelines which cannot cope with monsoonal rain. But the Chinese government has now adopted sponge cities as an urban planning and eco-city template.

Yu spoke in Melbourne on Tuesday at a symposium on water-conscious design held as part of Melbourne Design Week at the National Gallery of Victoria. Speaking to Guardian Australia ahead of his appearance, Yu, who is based in Beijing, explained the key benefit of sponge cities is the ability to reuse water. "The water captured by the sponge can be used for irrigation, for recharging the aquifer, for cleansing the soil and for productive use," Yu said.

"In China, we retain storm water and reuse it. Even as individual families and houses, we collect storm water on [the] rooftop and use the balcony to irrigate the vegetable garden." When it comes to water, the mottos of the sponge city are: "Retain, adapt, slow down and reuse."

His firm now has 600 employees and works across 200 cities in China. The firm has completed more than 600 projects and won a swag of major architecture and design awards. The strategies Yu uses are "based on peasant farming techniques, adapting peasant irrigation systems to urban environments and experience in adapting buildings to a monsoon climate".

The first strategy – "based on thousands of years of Chinese wisdom" – is to "contain water at the origin, when the rain falls from the sky on the ground. We have to keep the water".



Sponge cities 'contain water at the origin, when the rain falls from the sky on the ground'. *Source:* www.theguardian.com

"In China, there is a shortage of fresh water," Yu says. "China has only 8% of the fresh water of the world and feeds 20% of the population – so any fresh water from the sky will need to be kept in an aquifer."

Yu, who grew up on a farm and later studied architecture at Harvard, understands the need to be water conscious. "The ability to regulate water year-round in the dry season is a very critical strategy for the people to survive.

"One thing I learned is to slow down the process of drainage. All the modern industrial techniques and engineering solutions drain water away after the flood as fast of possible. So, modern tech is to speed up the drainage but ancient wisdom, which has adapted in the monsoonal season, was to slow down the drainage so the water will not be destructive anymore. By slowing the water it can nurture the habitat and biodiversity."

For Australia, and places where water is scarce: "When it's dry, keep the water on the ground in an aquifer, so it will not evaporate too much." Adaptation to drought conditions is also important: using as little water as possible, and recycling what there is.

As Yu says, it's important to "make friends with water". "We don't use concrete or hard engineering, we use terraces, learned from ancient peasantry wisdom. We irrigate. Then the city will be floodable and will survive during the flood. We can remove concrete and make a water protection system a living system." *Source:* https://www.theguardian.com/artanddesign/2018/mar/21/turning-cities-into-sponges-how-chinese-ancient-wisdom-is-taking-on-climate-change

German court rules cities can ban diesel cars to combat air pollution

February 2018 — Diesel cars could be banned from German cities within weeks to cut air pollution following a landmark court ruling on Tuesday.

In a decision that is thought could inspire similar moves across Europe, Germany's highest administrative court ruled that individual municipalities can ban older diesel cars from their streets in order to bring pollution levels down.

The ruling sent shares in German carmakers tumbling and caused widespread concern among diesel car owners that their vehicles could lose almost all their second hand value if they are banned from city streets.

Hamburg, Germany's second-largest city, said it would impose a ban on some of its most polluted streets "within a few weeks", and other major cities including Düsseldorf and Stuttgart, the home of Mercedes and Porsche, are expected to follow.

Angela Merkel sought to calm public concerns over the ruling. "It's about individual cities where more needs to be done," she said. "It's not really about the whole country or all the car owners in Germany."

Any diesel bans will be watched closely across Europe and could be copied by other countries as they seek to find ways to lower pollution levels.

The UK and Germany are among several countries facing the threat of legal action from the European Commission unless they do more to solve the problem.

Tuesday's court ruling was a victory for German Environmental Aid (DUH), an NGO which sued Stuttgart and Düsseldorf, two of Germany's most polluted cities, in order to force them to implement bans.

"This is a great day for clean air in Germany," Jürgen Resch, the head of the NGO said. "What we're seeing here is a debacle for the government, which sided with the car industry."

Greenpeace also welcomed the decision. "Every city can now defend its citizens' right to clean air," a spokesman said.

But it was greeted with dismay by business groups. "We continue to strongly oppose bans and call on local communities and cities to do everything they can to avoid them," The Central Association of German Crafts (ZDH) said in a statement.

"In a commuter country, we also have to think of those who have a small budget, cannot afford the latest car model and cannot get to work by bicycle," Julia Klöckner, named as agriculture minister by Mrs Merkel a few days ago, said.

Under the ruling, cities where air pollution exceeds the official limits will be able to issue their own bans on older diesel cars without authority from the central government.

Certain businesses which rely on diesel vehicles will be granted an exemption. But the court ruled that diesel owners whose vehicles were banned were not entitled to compensation.

At the moment there is no clear definition of which diesel models will be affected, and there were calls on Tuesday for Mrs Merkel's government to introduce a new national "blue badge" to indicate which cars are clean.

There have also been calls for carmakers to be forced to pay the cost of upgrading older vehicles to modern emissions standards.

Shares in Volkswagen fell 2.3 per cent in the immediate aftermath of the ruling. BMW fell 1 per cent and Daimler, the company that makes Mercedes, fell 0.6 per cent.

While some municipalities welcomed the decision, others were not so happy. The case only reached the courts because the regional governments in Stuttgart and Düsseldorf opposed a ban.

In Hamburg, however, officials were in a hurry to implement a ban. "Diesel restrictions in Hamburg will probably be the first nationwide," Jens Kerstan, the head of the city's environment department said. "We can order the signs today and have them in place within a few weeks."

– Justin Huggler

List of countries banning fossil fuel vehicles

Country	Ban announced	Ban commences	Scope
Norway	2016	2025	Gasoline or diesel
Germany	2017	2030	Gasoline or diesel
Britain	2017	2040	Gasoline or diesel
India	2017	2030	Gasoline or diesel
Holland	2017	2030	all vehicles emission free
France	2017	2040	Gasoline or diesel
Ireland	2018	2030	Gasoline or diesel
China	2018	Undetermined	Gasoline or diesel

Source: https://www.telegraph.co.uk/news/2018/02/27/german-court-rules-cities-can-ban-diesel-cars-combat-air-pollution/

Urban Aerodynamic Roughness and Wind-Speed Estimation

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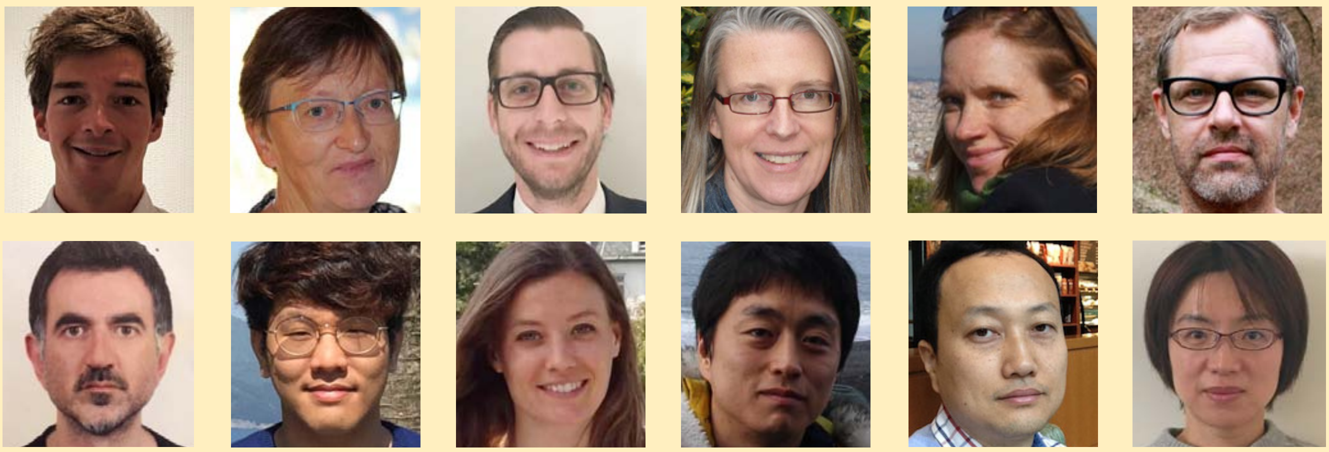

Introduction

An accurate model to estimate the vertical profile of wind speed with just a few readily available parameters is appealing to meteorologists and engineers for applications including numerical weather prediction, urban heat island effects, pollutant dispersal, ventilation, construction and wind energy generation. The aerodynamic roughness parameters, zero-plane displacement (z_d) and roughness length (z_0), are critical attributes to the wind-speed profile. Conceptually, z_d is the vertical displacement of the wind-speed profile due to surface roughness elements, whilst z_0 is the height at which wind speed becomes zero in the logarithmic wind-speed profile in the absence of z_0.

Urban environments are amongst the aerodynamically roughest surfaces encountered (Grimmond et al. 1998, Grimmond and Oke 1999, Wieringa et al. 2001), characterized by heterogeneous surface cover and roughness elements (e.g. type, height, shape, orientation). The consequential numerous sources and sinks of heat and momentum make it challenging to assign appropriate values for roughness parameters (z_0 and z_d), which has implications for associated wind-speed estimates. Here, results from five studies contributing to the understanding of urban roughness parameter and wind-speed estimation are summarized. With rapid growth of cities and their consequential changing form, results inform current processes and vulnerabilities, as well as the implications of future change.

Comparison of existing methods[1]

Three categories of methods exist to determine z_d and z_0: reference-based, anemometric and morphometric. Reference-based approaches require comparison to previously published pictures or look-up tables (Grimmond and Oke 1999, Stewart and Oke 2012), anemometric methods use in-situ observations (Grimmond et al. 1998) and morphometric methods are based upon roughness-element form (Grimmond and Oke 1999). The morphometric methods can be divided into two types based upon the attributes of roughness elements considered: (i) 'RE_{av}' type assume all roughness elements are the same height (represented by their average height) and (ii) 'RE_{var}' type directly incorporate roughness-element height variability (e.g. through the maximum and/or standard deviation of roughness-element heights) (Kent et al. 2017a). A range of methods also exist to estimate the wind-speed profile.

At three London (UK) sites (Fig. 1a), a selection of methods are used to estimate roughness parameters and the wind-speed profile, which are summarized in Table 1 (see Kent et al. 2017a and 2018 for method selection). The morphometric methods are applied using an iterative procedure with a source area footprint model to indicate the probable upwind surface area contributing to turbulent fluxes.

[1] This section summarises Kent et al. (2017a) and Kent et al. (2018).

Table 1. Methods applied to estimate: (a) roughness parameters and (b) wind-speed profile.			
(a) Methods to determine roughness parameters			
Reference	Abbreviation	Method type	Background to method
Raupach (1994)	Rau	Morphometric (RE_{av} type)	Data from wind tunnel and rough vegetated surfaces
Bottema & Mestayer (1998)	Bot		Simplification of Bottema (1995) for urban application
Macdonald et al. (1998)	Mac		Fundamental principles informed by wind-tunnel data
Grimmond & Oke (1999)	RT		Rule of thumb from synthesis of experimental/field data
Millward-Hopkins et al. (2011, 2013)	Mho	Morphometric (RE_{var} type)	Simplification of Millward-Hopkins et al. (2011) using elevation data from Leeds, UK
Kanda et al. (2013)	Kan		Numerical experiment of site in Tokyo, Japan
Grimmond et al. (1998)	EC	Anemometric (z_0)	Rearrangement of logarithmic wind law
Rotach (1994)	TVM	Anemometric (z_d)	Surface layer similarity relations of non-dimensional temperature (TVM) and vertical velocity (WVM) variance
Toda and Sugita (2003)	WVM		
(b) Methods to estimate wind-speed profile			
Reference		Background to method	
Blackadar and Tennekes (1968)		Logarithmic wind law from asymptotic similarity theory	
Sedefian (1980)		Power law considering z_d and z_0 in exponent	
Deaves and Harris (1978)		Adapted asymptotic similarity theory using modulus of wind speed	
Gryning et al. (2007)		Mixing length theory	

Considerable inter-method variability exists in the roughness parameters, with ranges for z_d between 5 and 45 m and z_0 between 0.1 and 5 m (e.g. Fig. 1b and c). The z_d values determined by the morphometric methods that directly consider roughness-element height variability (RE_{var} type) are consistently larger than the local average building height, H_{av} ~20 m, and up to twice the magnitude of the RE_{av} morphometric methods. There is agreement between the anemometric methods and RE_{var} morphometric methods that z_d is larger than H_{av}. This conclusion is consistent with results from recent numerical and physical experiments (e.g. Jiang et al. 2008, Hagishima et al. 2009, Zaki et al. 2011) indicating the taller roughness elements in a heterogeneous mix exert a disproportionate amount of drag on the flow (Xie et al. 2008, Mohammad et al. 2015) acting to increase z_d.

Wind speeds are estimated up to 200 m above the canopy (~10H_{av}) during strong winds (defined as the upper quartile of wind speeds), with roughness parameters from different methods assessed. For the most homogeneous upwind surface (Fig. 1a), initial estimates with the logarithmic wind law reveal wind speeds observed with Doppler lidar are underestimated using roughness parameters from morphometric methods which do not directly consider height variability (RE_{av} type), whilst estimates are most accurate with the RE_{var} method parameters (Fig. 2). Considering directions with greater surface heterogeneity, wind-speeds are consistently most accurate using the RE_{var} type roughness parameters, however the Deaves and Harris (1978) and Gryning et al. (2007) wind-speed profile methods are most appropriate. The choice of method to determine roughness parameters also has implications for source area modelling, with source areas varying by a factor of up to three depending upon whether RE_{av} or RE_{var} method parameters are used (e.g. Kent et al. 2017a, their Fig. 8).

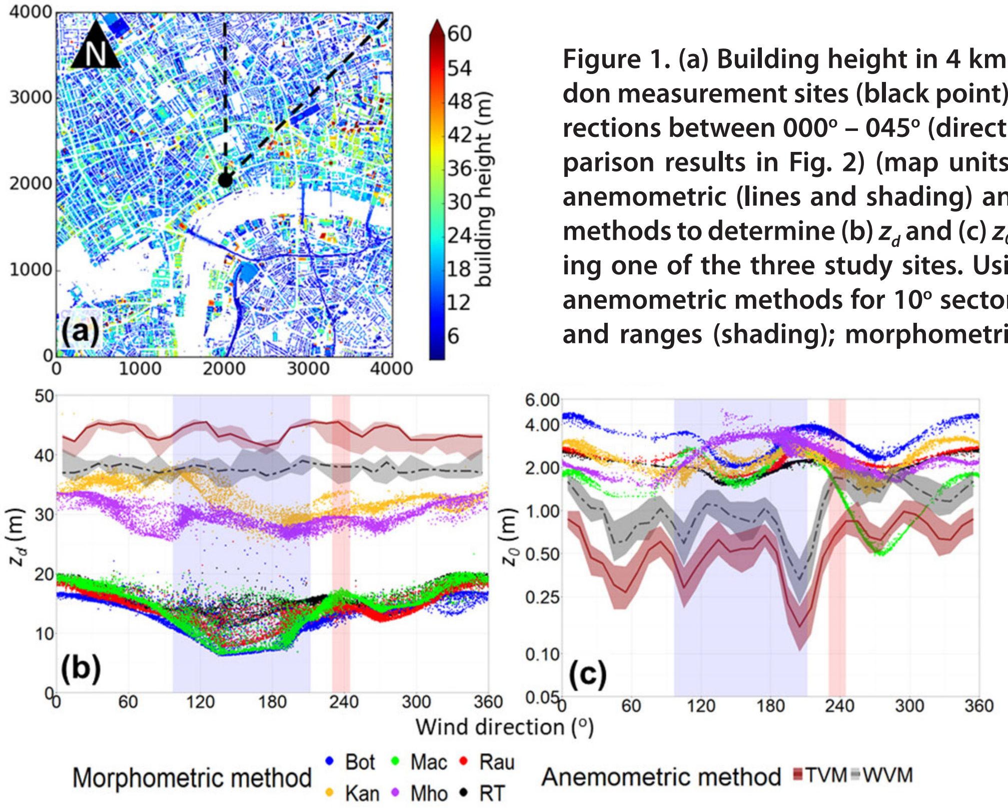

Figure 1. (a) Building height in 4 km x 4 km surrounding London measurement sites (black point), dashed lines indicate directions between 000° – 045° (directions for wind-speed comparison results in Fig. 2) (map units: metres). Comparison of anemometric (lines and shading) and morphometric (points) methods to determine (b) z_d and (c) z_0 (note ln y axis) surrounding one of the three study sites. Using observations in 2014: anemometric methods for 10° sectors with the median (lines) and ranges (shading); morphometric methods for individual source areas. Background shading: directions of River Thames (blue) and turbulence data disturbance (red). See Table 1a for method abbreviations and Kent et al. (2017a) for further comparison details.

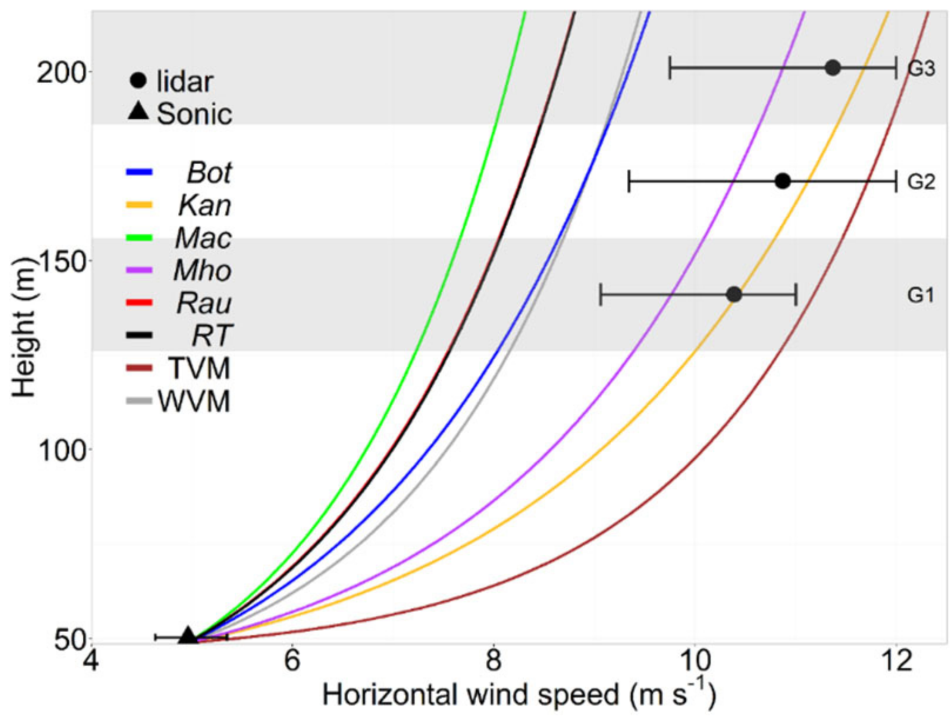

Figure 2. Average of hourly wind speeds observed with a sonic anemometer (triangle) and Doppler lidar (circles) for the fastest 25% of daytime (0900 – 1700 hrs) wind speeds from the 000° – 045° direction at central London sites (Fig. 1a) during measurement campaign (n = 33). Lidar wind speeds are for each 30-m wind gate (shaded G1 – G3). Whiskers show inter-quartile range of observed wind speeds. The average of wind-speed estimations using the logarithmic wind law with aerodynamic parameters (z_d and z_0) from different methods (coloured lines) are shown. See Table 1a for method abbreviations. Source: adapted from Kent et al. 2017a.

Morphometric method development: Buildings and vegetation[2]

Morphometric methods have been developed to estimate z_d and z_0 either for vegetated canopies (e.g. Nakai et al. 2008) or buildings (e.g. Table 1a) separately. Vegetation is typically ignored in urban studies to reduce complexity (e.g. Grimmond et al. 2010, 2011), however at lower aerodynamic porosities the drag of a porous roughness element (e.g. tree) may be as large as bluff bodies of similar shape (Kent et al. 2017b, their Fig. 1). Therefore, the Macdonald et al. (1998) morphometric method (RE_{av} type) is developed to incorporate both buildings and vegetation (Kent et al. 2017b). The development also applies to the Kanda et al. (2013) method, which incorporates height variability (RE_{var} type).

Observations from an urban park (Seoul, South Korea) and residential neighborhood (Swindon, UK) demonstrate the response of roughness parameters to vegetation (Kent et al. 2017c). At the urban park, inter-seasonal analysis indicates leaf-on z_d is 1 – 4 m larger than leaf-off and leaf-on z_0 is consistently >0.5 m smaller than leaf-off. The z_0 results highlight that considering vegetation in addition to buildings (or indeed an increase in any roughness-element packing density) does not necessarily lead to a larger z_0, as the change depends upon canopy density (e.g. Grimmond and Oke 1999, Nakai et al. 2008). In the suburban neighbourhood, not considering vegetation leads to an average reduction of 20% for z_d and 40% for z_0, which compares to a reduction of up to 50% in more densely vegetated suburban locations (Giometto et al. 2017). Wind-speed estimates with roughness parameters calculated considering both buildings and vegetation can be >25% more accurate, compared to when omitting vegetation (e.g. Fig. 3), with the greatest improvement in accuracy in directions with most vegetation cover. Consistent with the London results (Fig. 2), wind-speed estimates are more accurate with roughness parameters from an RE_{var} type morphometric method (Fig. 3).

[2] This section summarises Kent et al. (2017b and 2017c).

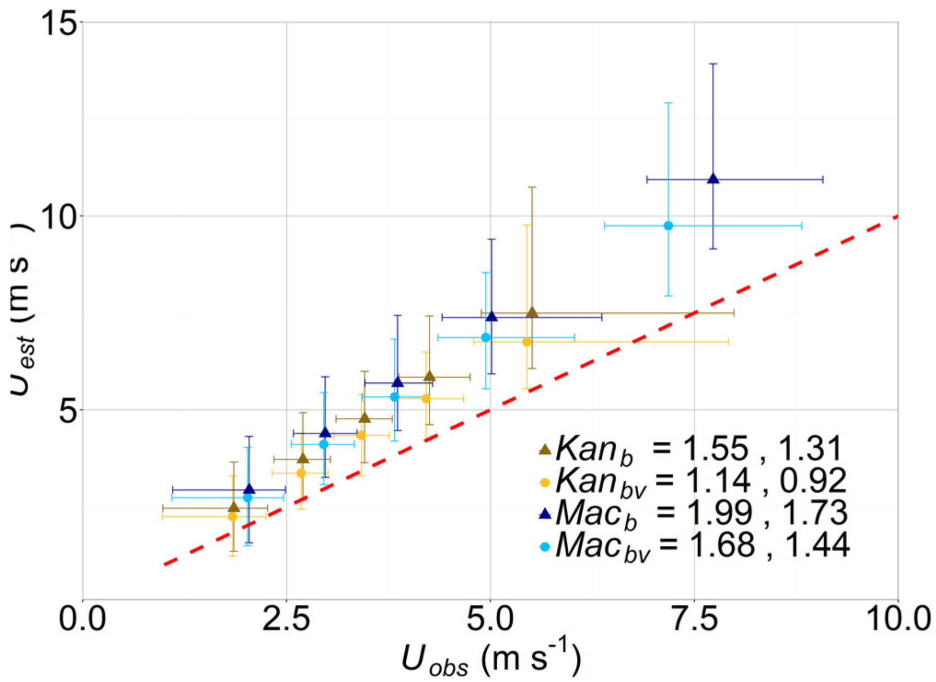

Figure 3. Observed (U_{obs}) and estimated (U_{est}, using the logarithmic wind law) wind speeds for 30-min wind-speed averages during neutral atmospheric stability for two years of observations in a suburban neighborhood (Swindon, UK) (observations at 2.8 times local average roughness-element height). Roughness parameters from the Macdonald et al. (1998, *Mac*) and Kanda et al. (2013, *Kan*) morphometric methods are used, considering buildings only (subscript *b*) or buildings and vegetation (subscript *bv*). Data binned from lowest wind speed in groups of 1250 (30-min) data points. Median (points) and 5th and 95th percentiles (error bars) shown. The root-mean-square error is followed by the mean absolute error (m s^{-1}) between U_{est} and U_{obs} in the legend. Source: Kent et al. 2017c.

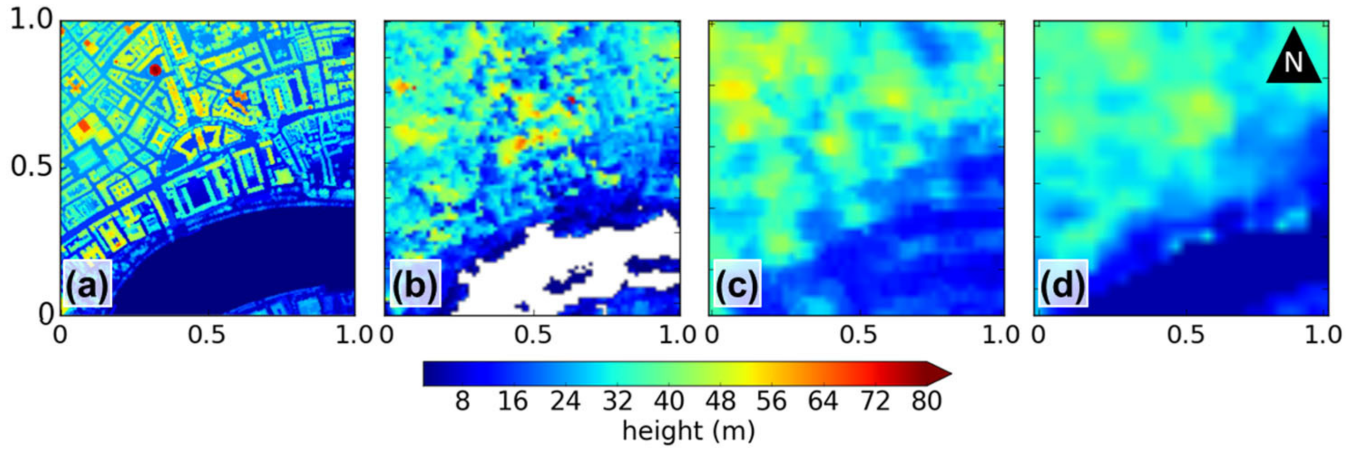

Figure 4. Digital surface model (ground + roughness-element height) of 1 km x 1 km grid-square in central London: (a) benchmark data, (b) TanDEM-X with water mask, (c) ASTER, (d) SRTM. Map units: km.

Global urban morphology

Global digital elevation models (GDEMs) can be used to retrieve urban morphology of cities globally. This morphology not only allows for estimation of roughness parameters (using morphometric methods) and associated wind speeds, but is becoming increasingly critical for modelling the urban climate (Garuma 2017). GDEMs tend to have coarse resolution and the methods used to retrieve surface elevations have limitations in urban environments, such as layover effects of buildings in close proximity or multi-scattering of radar. GDEMs from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), SRTM (Shuttle Radar Topography Mission) and TanDEM-X are compared to benchmark elevation datasets.

As the GDEMs have surface heights only (i.e. ground + roughness-element heights), a method was developed to extract ground heights from the GDEMs. Subtraction of ground heights from surface heights then yields a roughness-element surface model, allowing for geometric and roughness parameters to be calculated for discretized areas (i.e. 8 wind directions of 1 km x 1 km grid squares). Initial analysis in central London reveals errors from benchmark data were least for TanDEM-X (e.g. Fig 4 for a 1 km x 1 km area). Additional comparisons between TanDEM-X and benchmark data are being conducted in other strategically located (global) cities.

Summary and future prospects

The aerodynamic roughness parameters of zero-plane displacement (z_d) and roughness length (z_0) can be used with wind-speed profile laws to estimate the vertical profile of wind-speed above a surface. Characteristically rough urban environments mean assigning appropriate values for z_d and z_0 is challenging, impacting wind-speed estimates. Several studies are summarized which investigate roughness parameters and associated wind-speed estimates. Results highlight the importance of considering roughness-element height variability and vegetation when determining z_d and z_0, as well as informing the determination of urban morphology for cities on a global scale. Similar local studies elsewhere are facilitated by implementing the methodology to determine roughness parameters with morphometric methods and a source area footprint model in the Urban Multi-scale Environmental Predictor (UMEP) climate service plugin for the open source geographical information system software QGIS (Lindberg et al. 2018, http://www.urban-climate.net/umep/UMEP). Ongoing work is assessing the generalization of results to different cities.

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References

Blackadar AK, Tennekes H (1968) Asymptotic similarity in neutral barotropic planetary boundary layers. *Journal of the Atmospheric Sciences* 25:1015-1020.

Bottema M, Mestayer PG (1998) Urban roughness mapping–validation techniques and some first results. *Journal of Wind Engineering & Industrial Aerodynamics* 74:163-173.

Bottema M (1995) Aerodynamic roughness parameters for homogenous building groups - Part 2: Results. Ecole Centrale de Nantes, France Document SUB-MESO #23, 80 pp.

Deaves D, Harris R (1978) A mathematical model of the structure of strong winds. Construction Industry Research and Information Association Report number 76, London, England.

Garuma GF (2017) Review of urban surface parameterizations for numerical climate models. *Urban Climate*, DOI: https://doi.org/10.1016/j.uclim.2017.10.006

Giometto MG, Christen A, Egli PE, Schmid MF, Tooke RT, Coops NC, Parlange MB (2017) Effects of trees on mean wind, turbulence and momentum exchange within and above a real urban environment. *Advances in Water Resources* 106:154-168.

Grimmond CSB, Blackett M, Best M, Baik J, Belcher S, Beringer J, Bohnenstengel S, Calmet I, Chen F, Coutts A (2011) Initial results from Phase 2 of the International Urban Energy Balance Model comparison. *International Journal of Climatology* 31:244-272.

Grimmond CSB, Blackett M, Best M, Barlow J, Baik J, Belcher S, Bohnenstengel S, Calmet I, Chen F, Dandou A (2010) The international urban energy balance models comparison project: first results from phase 1. *Journal of Applied Meteorology and Climatology* 49:1268-1292.

Grimmond CSB, King TS, Roth M, Oke TR (1998) Aerodynamic roughness of urban areas derived from wind observations. *Boundary-Layer Meteorology* 89:1-24.

Grimmond CSB, Oke TR (1999) Aerodynamic properties of urban areas derived from analysis of surface form. *Journal of Applied Meteorology and Climatology* 38:1262-1292.

Gryning S, Batchvarova E, Brümmer B, Jørgensen H, Larsen S (2007) On the extension of the wind profile over homogeneous terrain beyond the surface boundary layer. *Boundary-Layer Meteorology* 124:251-268.

Hagishima A, Tanimoto J, Nagayama K, Meno S (2009) Aerodynamic parameters of regular arrays of rectangular blocks with various geometries. *Boundary-Layer Meteorology* 132:315-337.

Jiang D, Jiang W, Liu H, Sun J (2008) Systematic influence of different building spacing, height and layout on mean wind and turbulent characteristics within and over urban building arrays. *Wind and Structures* 11:275-289.

Kanda M, Inagaki A, Miyamoto T, Gryschka M, Raasch S (2013) A new aerodynamic parametrization for real urban surfaces. *Boundary-Layer Meteorology* 148:357-377.

Kent CW, Grimmond CSB, Barlow J, Gatey D, Kotthaus S, Lindberg F, Halios CH (2017a) Evaluation of Urban Local-Scale Aerodynamic Parameters: Implications for the Vertical Profile of Wind Speed and for Source Areas. *Boundary-Layer Meteorology* 164:183-213.

Kent CW, Grimmond CSB, Gatey D (2017b) Aerodynamic roughness parameters in cities: Inclusion of vegetation. *Journal of Wind Engineering and Industrial Aerodynamics* 169:168-176.

Kent CW, Lee K, Ward HC, Hong JW, Hong J, Gatey D, Grimmond CSB (2017c) Aerodynamic roughness variation with vegetation: Analysis in a suburban neighbourhood and a city park. *Urban Ecosystems*, DOI: https://doi.org/10.1007/s11252-017-0710-1

Kent CW, Grimmond CSB, Gatey D, Barlow JF (2018) Assessing methods to extrapolate the vertical wind-speed profile from surface observations in a city centre during strong winds. *Journal of Wind Engineering & Industrial Aerodynamics* 173:100-111.

Lindberg F, Grimmond CSB, Gabey A, Huang B, Kent CW, Sun T, Theeuwes NE, Järvi L, Ward HC, Capel-Timms I, Chang YY, Jonsson P, Krave N, Liu DW, Meyer D, Olofson KFG, Tan JG, Wästberg D, Xue L, Zhang Z (2018) Urban Multi-scale Environmental Predictor (UMEP) – An integrated tool for city-based climate services. *Environmental Modelling & Software* 99:70-87.

Macdonald R, Griffiths R, Hall D (1998) An improved method for the estimation of surface roughness of obstacle arrays. *Atmospheric Environment* 32:1857-1864.

Millward-Hopkins JT, Tomlin A, Ma L, Ingham D, Pourkashanian M (2011) Estimating aerodynamic parameters of urban-like surfaces with heterogeneous building heights. *Boundary-Layer Meteorology* 141:443-465.

Millward-Hopkins JT, Tomlin A, Ma L, Ingham D, Pourkashanian M (2013) Aerodynamic parameters of a UK city derived from morphological data. *Boundary-Layer Meteorology* 146:447-468.

Mohammad AF, Zaki, SA, Ali MSM, Aya H, Razak AA, Shirakashi M, Arai N (2015) Large Eddy Simulation of wind pressure distribution on heterogeneous buildings in idealised urban models. *Energy Procedia* 78:3055-3060.

Nakai T, Sumida A, Daikoku KI, Matsumoto K, van der Molen MK, Kodama Y, Kononov AV, Maximov TC, Dolman AJ, Yabuki H, Hara T (2008) Parameterisation of aerodynamic roughness over boreal, cool-and warm-temperate forests. *Agricultural and Forest Meteorology* 148:1916-1925.

Raupach M (1994) Simplified expressions for vegetation roughness length and zero-plane displacement as functions of canopy height and area index. *Boundary-Layer Meteorology* 71:211-216.

Rotach M (1994) Determination of the zero-plane displacement in an urban environment. *Boundary-Layer Meteorology* 67:187-193.

Sedefian L (1980) On the vertical extrapolation of mean wind power density. *Journal of Applied Meteorology and Climatology* 19:488-493.

Stewart ID, Oke TR (2012) Local climate zones for urban temperature studies. *Bulletin of the American Meteorological Society* 93:1879-1900.

Toda M, Sugita M (2003) Single level turbulence measurements to determine roughness parameters of complex terrain. *Journal of Geophysical Research: Atmospheres* (1984–2012) 108: 4363.

Wieringa J, Davenport AJ, Grimmond CSB, Oke TR (2001) New revision of Davenport roughness classification. In: Proceedings of 3EACWE, Eindhoven, The Netherlands, pp. 285-292.

Xie Z, Coceal O, Castro IP (2008) Large-eddy simulation of flows over random urban-like obstacles. *Boundary-Layer Meteorology* 129:1-23.

Zaki SA, Hagishima A, Tanimoto J, Ikegaya N (2011) Aerodynamic parameters of urban building arrays with random geometries. *Boundary-Layer Meteorology* 138:99-120.

Are detailed urban parameter datasets highly relevant for urban climate modelling?

The World Urban Database and Access Portal Tool (WUDAPT) is an innovative project already well known within the community (Ching et al., 2018; Mills et al., 2015). It allows for the mapping of Local Climate Zones (LCZ) in urban areas and their surroundings (Stewart and Oke, 2012) using remotely sensed satellite imagery (Bechtel et al., 2015; 2017). This project is the result of a tremendous involvement from the urban climate community and many peers have now joined or contributed to the WUDAPT effort. For instance, the open call for HUMINEX 2.0 in the June 2017 newsletter (Verdonck et al., 2017) or for the SUBLIME project last December (Steeneveld et al., 2017) demonstrated the enthusiasm surrounding WUDAPT within related fields of study and across the IAUC community. Several recent contributions have used information gathered out of the LCZs for modelling the urban climate in both detailed and simplified urban canopy models (Brousse et al., 2016; Alexander et al., 2016 Wouters et al., 2016). As this information is extracted out of the ranges of urban canopy parameters proposed by Stewart and Oke (2012), the current study sought to assess whether detailed urban canopy parameters obtained from other sources are of high relevance for properly modelling the urban climate. To perform this evaluation, we used the BEP-BEM (Martilli, 2002; Salamanca et al., 2010a; 2010b) urban canopy model embedded in the WRF 3.2 model (Chen et al., 2011) at a horizontal resolution of 500 m. This short article sums up the work that was done and published under Hammerberg et al. (2018).

Table 1. Representative periods and some key indicators (extracted out of Hammerberg et al., 2018)

Date	Mean temperature (°C)	Diurnal range (K)	Mean wind speed (m s-1)
7–9 January	−1.62	5.13	1.64
8–10 February	−0.32	4.31	5.00
20–22 March	6.93	15.24	0.69
21–23 April	15.00	12.30	2.49
5–7 July	27.26	16.13	1.56

Study Area and Methodology

The study was centered on the city of Vienna, Austria, which is characteristic of a Central European city in terms of urban morphology and architecture. The center of the city is defined by a dense urban continuum, which had historically been surrounded by medieval fortifications. During the 19th century, a ring of districts composed predominantly of 4 to 6 story Gründerzeit apartment blocks were built, encircling the old town. Beyond this central development the city experienced high rates of urbanization, incorporating historic villages and filling the gaps with modern constructions. Within the municipal boundaries of Vienna are currently living 1.8 million residents (Lukacsy and Fendt, 2015), stressing the need to better understand the climate in such a populated area.

Although the case study is interesting as such, since very little WRF urban climate modelling has been performed over European cities, the Austrian capital was selected in particular for its availability of both high resolution urban landscape information, in the form of GIS data (ie. building heights, building fraction, impervious area…), and weather data records (official and crowd-sourced). The latter were used to prescribe five 48-h study periods to evaluate the model sensitivity to different urban canopy parameters under five different representative climate conditions (Table 1). The selection of those periods was done by performing a k-means cluster analysis method over the hourly weather data provided by Austria's Zentralanstalt für Meteorologie und Geodynamik (ZAMG) for the Schwechat Airport.

The GIS data served mapping the city in the form of Local Climate Zones at 100-m scale in order to compare it to a satellite based LCZ map obtained from the WUDAPT framework. It also served to characterize distinct urban forms that were implemented afterwards in the BEP-BEM model in the form of urban canopy parameters (Figure 1), this case being named *ViennaGIS*. Indeed, as the mappings presented some differences, with an agreement of only 67%, especially between classes of adjacent and similarly structured classes such as LCZ 6 and 9 (Open Lowrise and Sparsely Built) or LCZ 2 and 5 (Compact and Open Midrise), it was assumed that when implemented at 500 m in the WRF model using the WUDAPT to WRF (W2W) protocol (Martilli et al., 2017) those disparities would result only in small changes, all located within the city boundary. Moreover, as the GIS data was only available for the municipality of Vienna, other assumptions about the landscape outside of those boundaries would have been necessary. Hence, we used

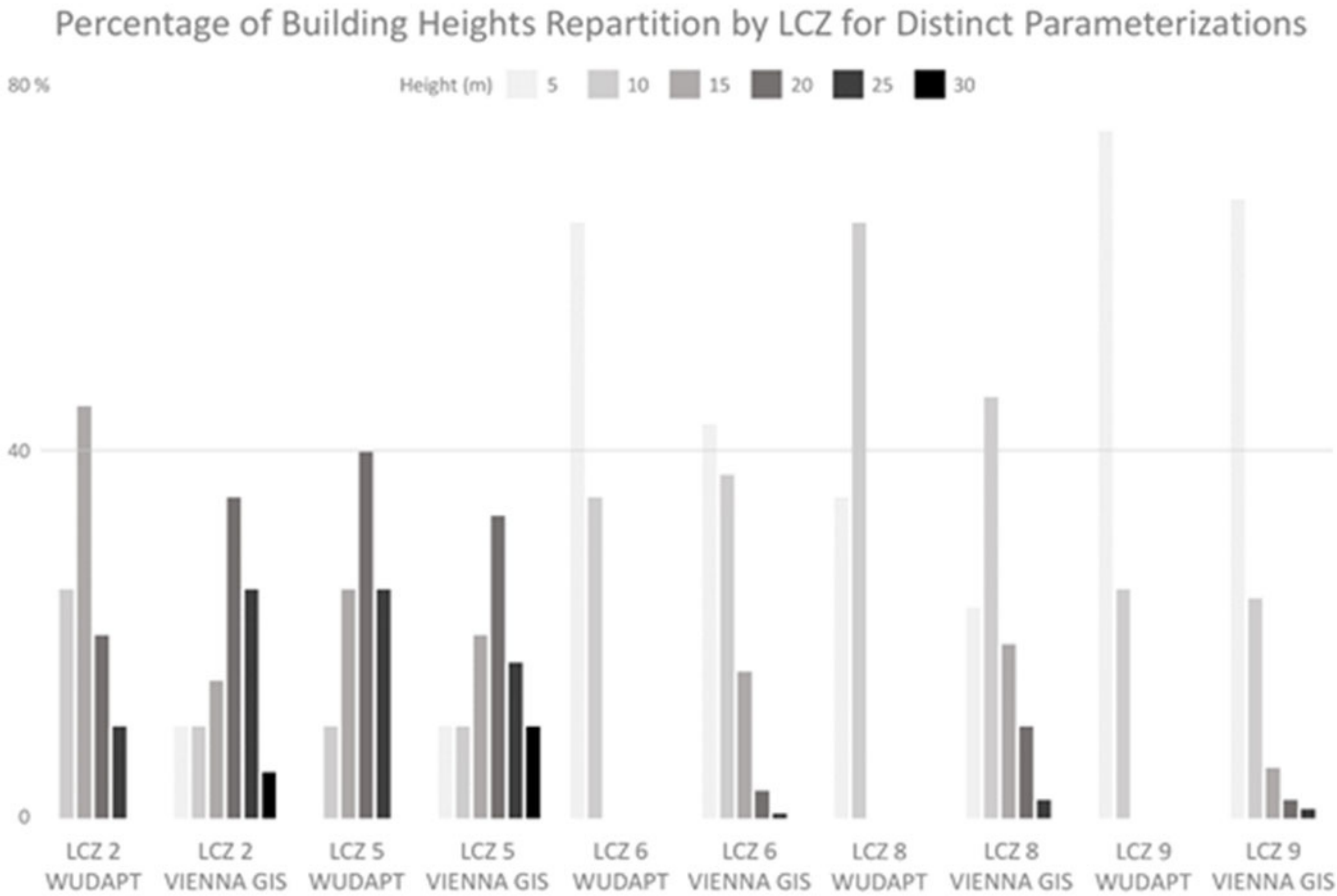

Figure 1. Building height distribution by LCZ (extracted out of Hammerber et al., 2018).

the WUDAPT mapping for representing the urban land cover but defined distinct urban environments based on the two sources of data.

Finally, we ran the model for the five periods with a spin up time of 6 h, using the NCEP Final Analysis data at 1º and 6-h spatio-temporal resolution as boundary conditions. The urban domain consisted of the fourth nested domain at 500-m resolution and was composed of 112 x 118 grid points. The urban landscape represented 11% of the total land cover, the remaining rural land use was described by the default MODIS global land cover classification available in WRF. The model outputs

Table 2. Near-surface temperature results for both urban canopy parameter cases. Day and Night values are given for all the five months together.

	Vienna GIS								WUDAPT							
	All	Day	Night	Jan	Feb	Mar	Apr	Jul	All	Day	Night	Jan	Feb	Mar	Apr	Jul
RMSE	2.61	2.50	2.72	2.67	1.57	3.71	2.15	2.45	2.65	2.52	2.78	2.72	1.58	3.79	2.18	2.48
MAE	1.99	1.94	2.03	2.02	1.23	3.05	1.66	1.94	2.01	1.96	2.06	2.06	1.24	3.09	1.67	1.97
MB	0.56	0.07	1.06	1.60	0.44	2.71	−1.11	−0.63	0.62	0.09	1.17	1.66	0.48	2.76	−1.08	−0.53
Mean	9.98	12.61	7.36	0.00	0.06	9.48	13.78	26.55	10.04	12.63	7.48	0.08	0.11	9.55	13.82	26.65
SD	10.49	11.29	8.90	2.88	2.10	3.72	3.32	5.04	10.48	11.26	8.94	2.87	2.09	3.57	3.27	4.99
Min	−7.24	−5.25	−7.24	−7.24	−5.25	0.44	4.28	13.77	−7.13	−5.20	−7.13	−7.13	−5.20	0.63	4.35	13.85
Max	35.1	35.1	31.87	9.43	4.98	18.1	20.1	35.1	36.1	36.1	31.90	9.33	4.97	18.3	20.4	36.1

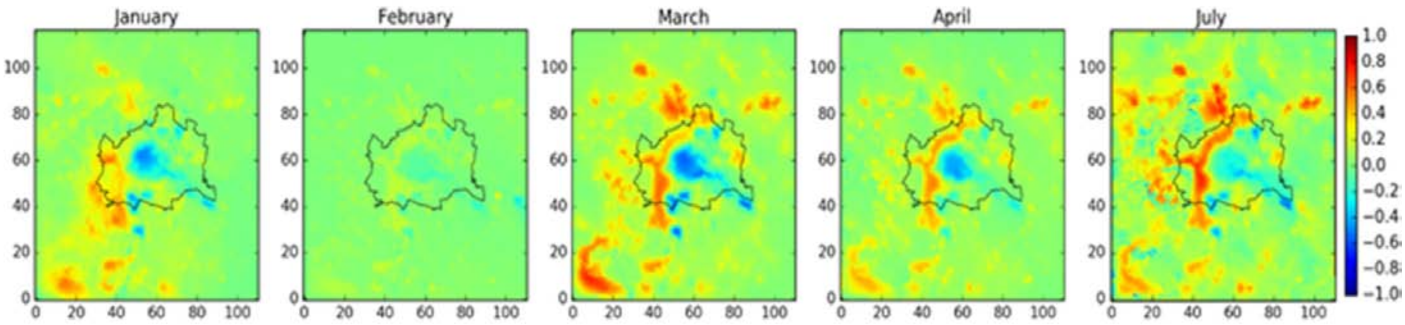

Figure 2. Air temperature difference in Kelvin between WUDAPT and ViennaGIS cases for each period (extracted out of Hammerberg et al., 2018)

were evaluated against both official and crowdsourced weather data extracted out of Wunderground for 2-m air temperature using RMSE and Mean Bias (MB) indicators. The filtering of the crowdsourced data followed the same kind of filter used by Meier et al. (2017) and Fenner et al. (2017). In the end, the network comprised 150 stations. More information about the methodology can be found in Hammerberg et al. (2018).

Results summary

Contrary to our expectations, the runs using the WUDAPT data exhibited only a slightly higher RMSE and mean bias in comparison to the ViennaGIS case with differences lower than 0.1 K for both the RMSE and the MB (Table 2). In general, the model tended to overestimate the temperatures except for hot days in April and July. The best case was the February case, while the cloudiest days of March experienced the worst performances. Although the different urban morphologies exhibited nearly identical seasonal and diurnal patterns in terms of overall performances, we paid particular attention to the spatial distribution of the error. Two evaluations were hence performed: first, a cumulative absolute error was derived per LCZ for both WUDAPT and ViennaGIS cases during nighttime; second a difference map of the mean overnight air temperature was created for each season.

The cumulative absolute error did not present major differences of performance per LCZ for the two cases. Still, interestingly LCZ 6 (Open Lowrise) demonstrated the higher disparity between ViennaGIS and WUDAPT in terms of performances. This class was also the one with the higher disagreement in terms of mappings and morphological characteristics. Yet, the most surprising outcome of this study was that despite a tangible variation in cumulative error graphs per LCZ, a systematic difference in air temperature between the two urban definitions was observed (Figure 2). This difference could be up to 1 K in certain places which could induce large differences in terms of impact of the urban heat island for instance. Generally speaking, the WUDAPT parameterization presented hotter suburban areas (LCZ 6 and 9) while it presented a cooler urban center (LCZ 2 and 5).

The main hypothesis was that this pattern is mainly explained by a radiative trapping phenomenon as the increase in building heights and H/W ratios in central areas for the ViennaGIS case and in the suburban areas for the WUDAPT case allow for more radiative trapping and less cooling capacity. This was actually confirmed by the peculiar case of LCZ 8 (Large Lowrise), which presented higher temperatures in the ViennaGIS case although the building heights and the urban fractions were similar to the WUDAPT ones. Yet, the streets were much narrower for the ViennaGIS case, supporting the idea that the BEP-BEM modelled air temperature is highly sensitive to the radiative trapping.

Discussion and conclusion

This evaluation supported the hypothesis presented by Grimmond et al. (2010; 2011) and Demuzere et al. (2017) that model results are highly influenced by the parameterization of urban canyons and not only by the complexity of the models. However, their relative performances when compared to measurements seem to be affected by other parameters. We give hereby a short overview of the challenges that the community has to face in that regard:

- Firstly, the location of the city has to be taken into account prior to any analysis or even model parameterizations. Complex terrain, like the orography surrounding Vienna, might be complicated to represent by regional climate models in which urban canopy models are embedded and hence bias our assumptions at urban scales.
- Secondly, for our case study the BEP-BEM model is known to be a very complex model and, as Jänicke et al (2016) showed over Berlin, model complexities often increment the margin of error.
- Thirdly, up until the development of new techniques, such as RANS or LES algorithms (Nazarian and Kleissl,

2015; Li et al., 2017), allowing downscaling dynamically at very high resolution, the simplification of the urban morphology before running the model introduces already a margin of error that affects our ability to properly evaluate and use very detailed urban information. In that sense, simplified data coming out of WUDAPT are very useful at our current level of modelling.

- Fourthly, even if detailed information is available, it is often (not to say all the time) constrained within municipal boundaries. This hinders our capacity as mesoscale urban climate modellers to properly represent the impact of the whole urban area on the local climate as we would anyhow have to make assumptions about the surrounding urban morphology.
- Finally, this study allowed us to demonstrate (more information is available in the paper) that the use of crowdsourced data for evaluation of our models is not only an opportunity (Chapman et al. 2016), but possibly a necessity. Such data, when filtered and calibrated, offers an unprecedented spatial coverage of urban measurements, something that is often lacking when using only official weather station networks. However, we acknowledge that those data have their margins of error and we therefore encourage the community to continue proceeding with innovative evaluations in that sense.

As a final note, this study offered us the ability to evaluate how we can emancipate ourselves from former boundaries within our field of study, especially regarding data availability for both parameterization of our models and also evaluation. It is our duty to remain critical and thoroughly evaluate datasets each time they are to be used. However, we are pleased to see that in the current state-of-the-art, crowdsourced weather data or innovative approaches for data gathering – like the WUDAPT project – are providing tremendous added values, particularly for scarcely documented areas such as the developing countries or even secondary cities of developed countries.

References

Alexander PJ, Bechtel B, Chow WTL, Fealy R, Mills G. 2016. Linking urban climate classification with an urban energy and water budget model: Multi-site and multi-seasonal evaluation. *Urban Climate* 17: 196-215.

Bechtel, B., Alexander, P.J., Böhner, J., Ching, J., Conrad, O., Feddema, J., Mills, G., See, L., Stewart, I., 2015. Mapping Local Climate Zones for a Worldwide Database of the Form and Function of Cities. ISPRS Int. J. Geo-Inf. 4, 199–219. doi:10.3390/ijgi4010199

Bechtel, B., Demuzere, M., Sismanidis, P., Fenner, D., Brousse, O., Beck, C., Van Coillie, F., Conrad, O., Keramitsoglou, I., Middel, A., Mills, G., Niyogi, D., Otto, M., See, L., Verdonck, M.-L., 2017. Quality of Crowdsourced Data on Urban Morphology—The Human Influence Experiment (HUMINEX). Urban Sci. 1, 15. doi:10.3390/urbansci1020015

Brousse, O., Martilli, A., Foley, M., Mills, G., Bechtel, B. (2016): WUDAPT, an efficient land use producing data tool for mesoscale models? Integration of urban LCZ in WRF over Madrid. *Urban Climate* 17, 116–134. doi:10.1016/j.uclim.2016.04.001

Chapman L, Bell C, Bell S. 2016. Can the crowdsourcing data paradigm take atmospheric science to a new level? A case study of the urban heat island of London quantified using Netatmo weather stations. *International Journal of Climatology*. doi:10.1002/joc.494

Chen F, Kusaka H, Bornstein R, Ching J, Grimmond CSB, Grossman-Clarke S, Loridan T, Manning KW, Martilli A, Miao S, Sailor D. 2011. The integrated WRF/urban modelling system: development, evaluation, and applications to urban environmental problems. *International Journal of Climatology* 31(2): 273-288.

Ching J, Mills G, Bechtel B, See L, Feddema J, Wang X, Ren C, Brousse O, Martilli A, Neophytou M, Mouzoudires P, Stewart I, Hanna A, …, Chen F. 2018. World Urban Database and Access Portal Tools (WUDAPT), an urban weather, climate and environmental modeling infrastructure for the Anthropocene. Submitted to the *Bulletin of the American Metorological Society*

Fenner, D., Meier, F., Bechtel, B., Otto, M., & Scherer, D. (2017). Intra and inter local climate zone variability of air temperature as observed by crowdsourced citizen weather stations in Berlin, Germany. *Meteorologische Zeitschrift*, 26, 525-547.

Grimmond CS, Blackett M, Best MJ, Barlow J, Baik JJ, Belcher SE, Bohnenstengel SI, Calmet I, Chen F, Dandou A, Fortuniak K. 2010. The international urban energy balance models comparison project: first results from phase 1. *Journal of Applied Meteorology and Climatology* 49(6): 1268-1292.

Grimmond CS, Blackett M, Best MJ, Baik JJ, Belcher SE, Beringer J, Bohnenstengel SI, Calmet I, Chen F, Coutts A, Dandou A. 2011. Initial results from Phase 2 of the international urban energy balance model comparison. *International Journal of Climatology* 31(2): 244-272

Hammerberg, K., Brousse, O., 2018. Implications of employing detailed urban canopy parameters for mesoscale climate modeling: A comparison between WUDAPT and GIS databases over Vienna, Austria. *International Journal of Climatology*. doi:10.1002/joc.5447

Jänicke B, Meier F, Fenner D, Fehrenbach U, Holtmann A, Scherer D. 2016. Urban–rural differences in near-surface air temperature as resolved by the Central Europe Refined analysis (CER): sensitivity to planetary boundary layer schemes and urban canopy models. *International Journal of Climatology* 37(4): 2063-2079

Li Q, Bou-Zeid E, Anderson W, Grimmond S, Hultmark M. 2016. Quality and reliability of LES of convective scalar transfer at high Reynolds numbers. *International Journal of Heat and Mass Transfer*, 102, 959-970.

Lukacsy M, Fendt C. 2015. Vienna in Figures 2015. Vienna: Vienna City Administration MA23. https://www.wien.gv.at/statistik/pdf/viennainfigures-2015.pdf (accessed March 13, 2016)

Martilli A. 2002. Numerical study of urban impact on boundary layer structure: Sensitivity to wind speed, urban morphology, and rural soil moisture. *Journal of Applied Meteorology* 41(12): 1247-1266.

Martilli A, Brousse O, Ching J. 2017. Urbanized WRF modeling using WUDAPT. Retrieved method from http://www.wudapt.org/wp-content/uploads/2016/05/Urbanized-WRF-modeling-using-WUDAPT-web-version-March2016.pdf

Meier F, Fenner D, Grassmann T, Otto M, Scherer D. 2017. Crowdsourcing air temperature from citizen weather stations for urban climate research. *Urban Climate* 19: 170-191.

Mills G, Ching J, See L, et al. (2015) Introduction to the WUDAPT project. In: Proceedings of the ICUC9. Meteo France, Toulouse, France.

Nazarian N, Kleissl J. 2015. CFD simulation of an idealized urban environment: thermal effects of geometrical characteristics and surface materials. *Urban Climate*, 12: 141-159.

Salamanca F, Krpo A, Martilli A, Clappier A. 2010. A new building energy model coupled with an urban canopy parameterization for urban climate simulations—part I. formulation, verification, and sensitivity analysis of the model. *Theoretical and Applied Climatology* 99(3-4): 331.

Salamanca F, Martilli A. 2010. A new Building Energy Model coupled with an Urban Canopy Parameterization for urban climate simulations—part II. Validation with one dimension off-line simulations. *Theoretical and Applied Climatology* 99(3-4): 345.

Stewart I, Oke TR. 2012. Local Climate Zones for Urban Temperature Studies. *Bulletin of the American Meteorological Society* 93(12): 1879–1900.

Wouters H., Demuzere M., Blahak U., Fortuniak K., Maiheu B., Camps J., Tielemans D., van Lipzig N.P.M. 2016. The efficient urban canopy dependency parametrization (SURY) v1. 0 for atmospheric modelling: description and application with the COSMO-CLM model for a Belgian summer. *Geoscientific Model Development* 9(9): 3027-3054.




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How high-resolution large-eddy simulation modelling is used to support urban planning in Helsinki, Finland

Introduction

Air pollution is one of the major environmental challenges urban areas are facing today. Over half of the World's population lives in urban areas, where pollutant emissions especially from road traffic and domestic heating are elevated (Karagulian et al., 2015). In 2016, the destructive health effects of pollutant exposure led to around 4.1 million premature deaths worldwide (Gakidou et al., 2017), of which almost 10% occurred in Europe (European Environment Agency, 2017).

Pollutant dispersion and air quality in urban areas depends strongly on the complex interaction between the atmospheric boundary layer (ABL) flow and local structures, i.e. buildings, vegetation and other obstacles. Commonly, the highest pollution levels are observed within street canyons with traffic where pollutants can accumulate due to inefficient dispersion and mixing conditions. In order to reduce human exposure to air pollutants within urban areas, the mechanisms affecting the dispersion conditions must be understood and examined in greater detail.

In Helsinki, Finland, urban planners have awoken to the possibility to influence pollutant dispersion via modifications in the urban landscape, and this way a joint project between the practitioners and urban climate scientists was initialised. The aim was to investigate how with proper urban planning we can minimize pedestrian level pollutant accumulation and enable a healthy living environment in a new planned neighbourhood in Helsinki.

The idea of this project was to apply high-resolution large-eddy simulation (LES) modelling to examine how the structural layout of densely arranged building blocks along a planned city boulevard in Helsinki influences the street canyon ventilation and concentrations of local air pollutants. More specifically, the accumulation and ventilation of traffic-related emissions were investigated in four city-block-design alternatives that are immersed within a real complex urban environment. Two contrasting meteorological conditions with a neutral and stable atmospheric stratification corresponding to general and wintry meteorological conditions were examined.

In the past, most of the urban ventilation studies using LES have been conducted for an idealised street canyon or a simplified urban topography without including the aerodynamic impact of street trees (see e.g. Antoniou et al., 2017 for an overview). Excluding this aerodynamic impact can be dangerous as, for example, porous trees decelerate the flow, generate turbulence and modify the canyon vortex (Gromke & Blocken, 2015) that is commonly observed in idealised street canyons, further altering the vertical transport of pollutants (Buccolieri et al., 2009). The availability of detailed urban topography and land use datasets (e.g. Nordbo et al., 2015) has extended the application of LES to real urban environments (Keck et al., 2014) over the last decade. Still, this LES study is among the first of its kind where complex landscapes with detailed building structures and vegetation have been included.

A planned city boulevard

In 2016, the city of Helsinki published the City Plan for 2050 which is driven by the expected increase of the population in Helsinki and its surroundings by up to 35% in the following 30 years (Vuori & Laakso, 2016). To enable sustainable urban growth, one of the key-elements in the plan is to urbanise the city northwards by transforming the motorway-type entry routes in the outer suburbs into urban 'city boulevards'. These boulevards would be framed by densely built neighbourhoods with business premises and shops at the ground level. Meanwhile, the city planners started to get interested in how to make these new neighbourhoods as lively and healthy as possible by means of minimising the pollutant concentrations in the neighbourhood. Despite improvements in public transport and technological developments, traffic emissions are expected to be substantial within these city boulevards. Therefore, alternative means to reduce the street level pollutant concentrations were looked for. This brought the need for this study where the focus is on one of the planned boulevards in western Helsinki (Figure 1).

The four alternative city-block-design versions (Table 1) for the studied boulevard are displayed in Figures 2 and 3. Each version facilitates an equal amount of gross floor area, and the width and total length of the boulevard are 54 m and 3.3 km, respectively.

A large forest lies to the east of the study area. Furthermore, two rows of street trees (*Tilia*) would be planted in the middle of the boulevard. The main local source of air pollution would be the road traffic on the boulevard but also on its cross streets.

High-resolution large-eddy simulation

The LES model employed is the Parallelized Large-Eddy Simulation Model (PALM) version 4.0 (Maronga et al., 2015), which resolves the three-dimensional fields of wind and scalar variables as a function of time and space. A Cartesian topography scheme allows for explic-

Figure 1. The modelling domain for the simulations with wintry meteorological conditions (light yellow line). The city-block-design structure V_{par} is superimposed on the map over Helsinki (©Kaupunkimittausosasto 2011, Helsinki, Finland) in orange and the road network in white. The analysis domain is marked with a green dashed line.

Table 1. The specific characteristics of the alternative city-block-design versions.

Version	*Characteristics*
V_{par}	The longest side of the building blocks is parallel to the boulevard. Building heights are fixed to 30 m.
V_{per}	The longest side of the building blocks is perpendicular to the boulevard. Building heights are fixed to 30 m.
V_{perHY}	Similar to V_{per} but the building height varies (mean 30 m). The highest buildings are situated at the nodal points of the public transport, whereas the lowest buildings as well as open urban spaces are situated between the nodal points. Buildings on the eastern side of the boulevard are generally higher.
V_{parJJ}	A so-called "Jin-Jang" block model, in which the buildings are similar to those in V_{par} but the base height is lower and tower-like structures are set above the base. Thus, the building shape and height (mean 30 m) are very irregular.

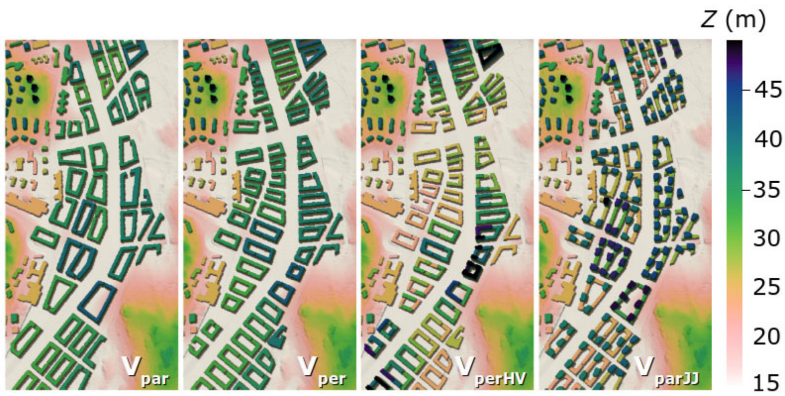


Figure 2. The different city-block-design alternatives. From left: V_{par}, V_{per}, V_{perHV} and V_{parJJ}.

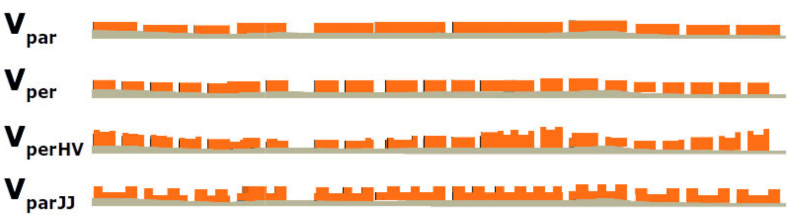


Figure 3. Vertical cross sections of the city-block-design alternatives.

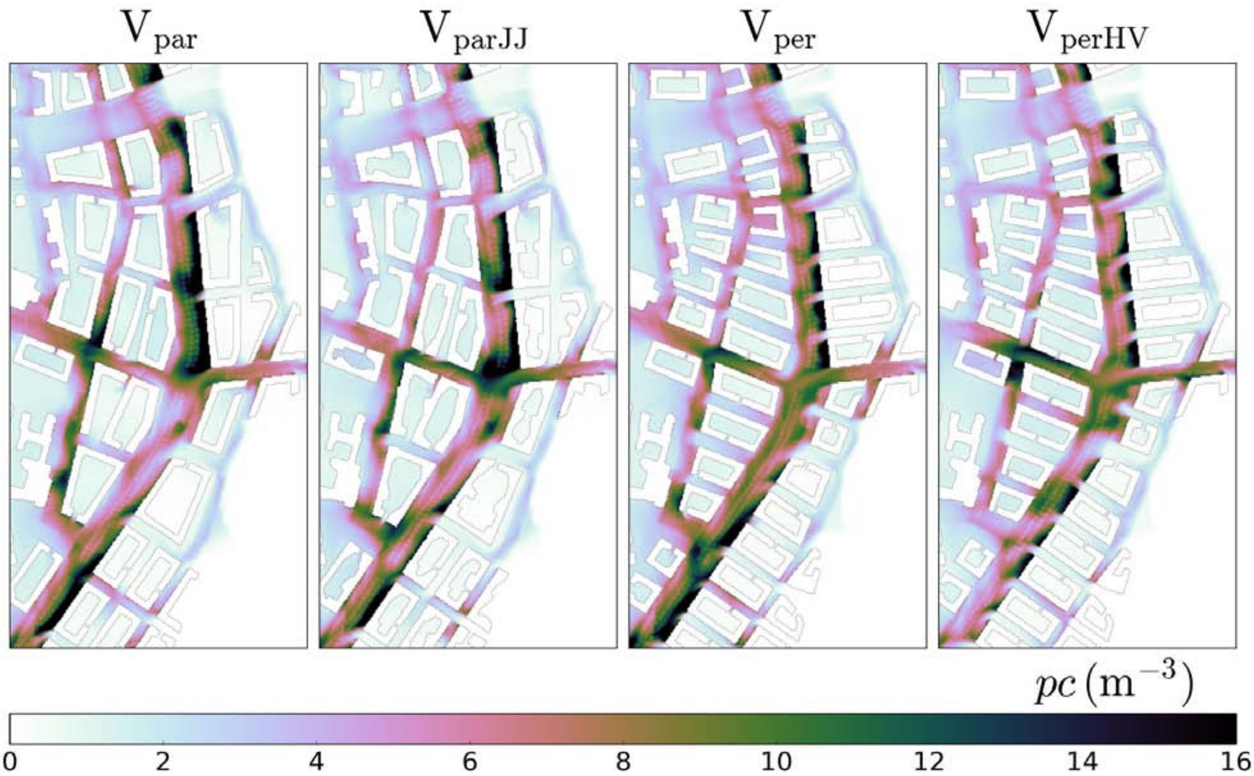


Figure 4. 40 minute temporal average of particle concentration *pc* (m^{-3}) at z = 4 m AGL under the wintry inflow conditions. The wind is from east (right).

itly resolving the orography and buildings that are given to the model in a raster map. The aerodynamic impact of vegetation is considered by an additional forcing term in the tendency equations of wind and turbulent kinetic energy. This term depends on the local plant area density (PAD), which is also given for the street trees and forest in a raster map.

Ventilation of traffic-related air pollutants is studied by applying a Lagrangian stochastic particle model, which allows pollutant accumulation inside urban structures to be studied. Lagrangian particles are released above streets at traffic-related emission rates, after which they are transported inside the computational domain by the flow field. Here, Lagrangian particles are passive and massless, and represent non-reactive gaseous air pollutants. Furthermore, deposition onto surfaces is not included.

As a new feature of PALM, a full three-dimensional two-way self-nesting (Hellsten et al., 2017) is utilised for the first time in this study. In nesting, a "child" domain of around 2 km^2 with a 1.0 m grid spacing is defined inside the "parent" domain of 4.2 km^2 with a 2.0 m grid spacing. PALM is run in parallel in both domains that communicate with each other. Nesting enables to have both a large computational domain and a high enough resolution in the main area of interest with limited computational costs.

In order to acknowledge the role of meteorology on pollutant ventilation, the simulations are conducted both under general and wintry inflow conditions. Under the general inflow conditions, the ABL is neutrally stratified and 200 m high, and the geostrophic wind is 10 m s^{-1} from southwest. Under the wintry conditions, the ABL is moderately stable and 160 m high, and the geostrophic wind is 8 m s^{-1} from east. Moreover, the winter-time leaf-off period is considered by decreasing PAD values by 80%.

Improved ventilation by proper planning

In this study we focus on ventilation, which addresses the capacity of a densely built urban structure to replace contaminated air with fresh ambient air and thus improve local air quality. The analysis of ventilation efficiency is based on three different measures: concentration *pc* (m^{-3}) at height z = 4 m and z = 10 m above ground level (AGL), vertical turbulent flux density *Fp* (m^{-2} s^{-1}) at z = 20 m AGL and dilution rate D (m^{-3} s^{-1}) of particles inside a volume between z = 0-20 m AGL if the emission source is suddenly switched off. Here only the temporal averages over a 40 minute period under the wintry inflow conditions are represented. Along with spatial visualisation, the measures are quantitatively analysed over the boulevard, other street canyons excluding the boulevard, courtyards, and surroundings. The analysis domain of 0.5 km^2 is marked in Figure 1.

In general, particle concentrations (Figure 4) are ap-

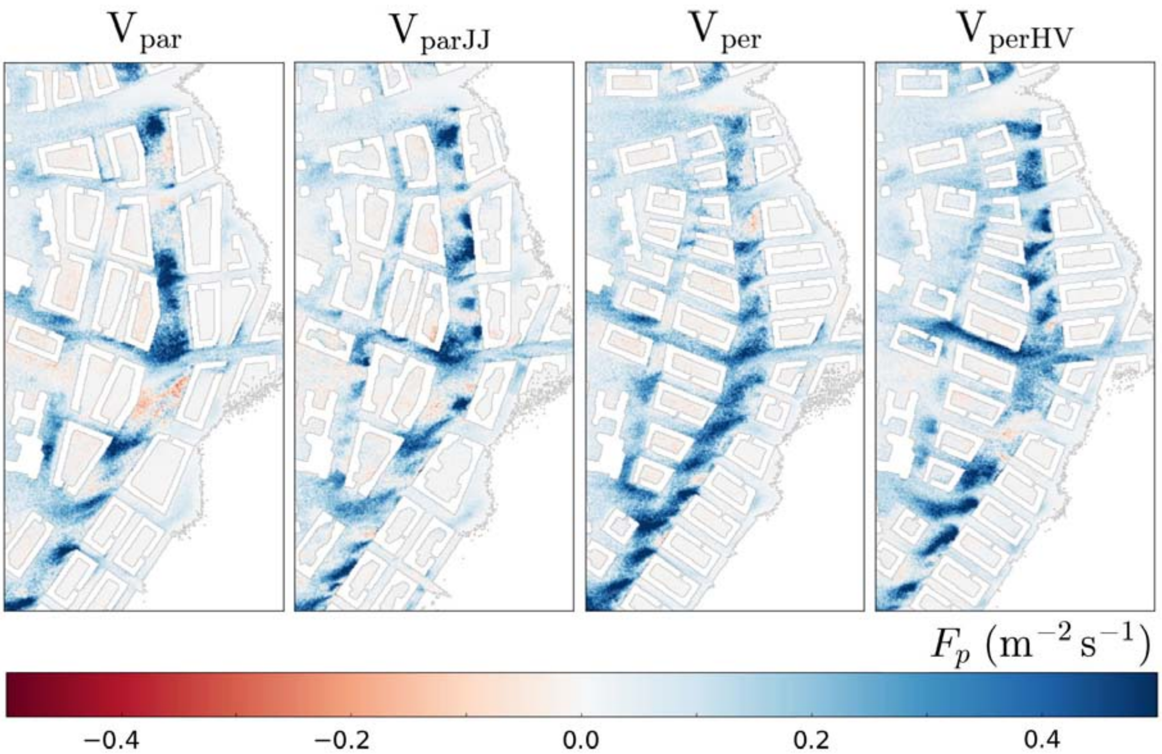


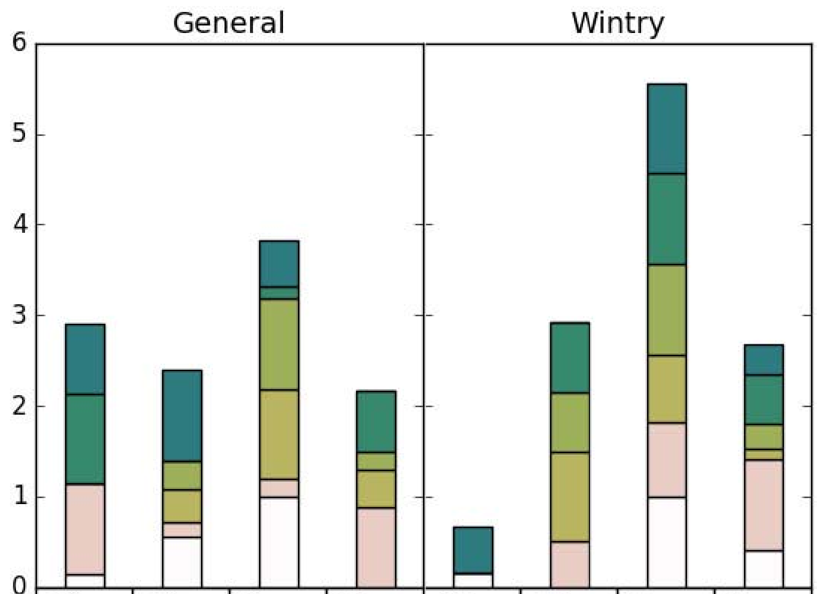
Figure 5. 40 minute temporal average of vertical turbulent particle flux density *Fp* (m^{-2} s^{-1}) at z = 20 m AGL under the wintry inflow conditions. Positive values indicate upward transport.

proximately two-fold under the wintry compared to the general inflow conditions despite the leaf-off period in winter. Clear accumulation of particles is observed on the leeward (eastern) side of the boulevard, but in general, *pc* varies strongly in the horizontal. The wind is from the east under the wintry inflow conditions and blows over the large forest area. Therefore, fresh unpolluted air is transported to the boulevard, decreasing the concentration levels. This is particularly emphasised in V_{per} and V_{perHV} with more cross streets. Surprisingly, V_{parJJ} with variation in the building shape does not show lower concentrations than V_{par}. In the southern part of the boulevard, concentrations are slightly lower in V_{perHV} than V_{per} despite the decreasing building height downwind in V_{perHV}, which is generally expected to weaken the canyon vortex and ventilation (e.g. Nosek et al., 2016). In all planning alternatives, the courtyards remain clean.

Particle flux is generally positive indicating upward transport and ventilation (Figure 5). This can be expected since there is a constant source of Lagrangian particles at surface. Above courtyards, *Fp* is mainly negative as the only sources are the re-entrainment from above or advection from building openings. The patterns of *Fp* for V_{par} and V_{parJJ} are clearly different despite the similarity in their concentration patterns. For instance, a vast area of *Fp* is observed above the boulevard in V_{par}, which appears less pronounced in V_{parJJ}.

Mechanical turbulence production is the major contributor to *Fp* and the largest values of *Fp* are always observed in V_{perHV} or V_{per}. On the contrary, the dilution rate *D*, i.e. the rate of change of concentration when the source is suddenly switched off, is always stronger under the wintry inflow conditions and measures mainly horizontal advection.

For urban planners and stakeholders, the information included in the three studied measures was transformed to a more easily comprehensible rating format (Kurppa, 2016). To list the alternative city-block-design version in order from best to worst, the versions were rated on a relative scale 0-1 based on each measure applied in the analysis separately over the boulevard, other street canyons, courtyards, and surroundings (Figure 6). Under both inflow conditions, the ventilation efficiency is highest in V_{perHV}, especially over street canyons. Within street canyons, V_{perHV} results in 7-9 % lower mean concentration a z = 4 m than the city-block-design version with highest concentrations. Surprisingly, V_{parJJ} with building-shape variation performs better than V_{par} only under the wintry inflow conditions. One reason for this negligible impact of higher aerodynamic roughness in V_{parJJ} is the relatively high building base height (20 m) above which the tower structures are erected. Moreover, concentrations remain low inside courtyards and also in the surroundings, which indicates that traffic-related emissions remain mainly within the street canyons. This also shifts the focus on the ventilation efficiency above street canyons.



	General				Wintry			
	V_{par}	V_{per}	V_{perHV}	V_{parJJ}	V_{par}	V_{per}	V_{perHV}	V_{parJJ}
pc : B	0.14	0.56	1.00	0.00	0.16	0.00	1.00	0.41
pc : O	1.00	0.16	0.19	0.88	0.00	0.50	0.82	1.00
pc : C	1.00	0.93	0.55	0.00	1.00	0.62	0.00	0.43
pc : S	1.00	0.00	0.77	0.91	0.70	0.00	0.97	0.94
F_p : B	0.00	0.36	1.00	0.42	0.00	1.00	0.74	0.12
F_p : O	0.00	0.32	1.00	0.19	0.00	0.65	1.00	0.27
F_p : C	0.29	0.00	0.68	1.00	0.00	0.05	1.00	0.19
F_p : S	0.18	0.46	1.00	0.00	0.17	1.00	0.70	0.00
$\langle D \rangle_V$	1.00	0.00	0.42	0.09	0.00	0.55	1.00	0.20
$\langle D \rangle_{z,t}$: B	1.00	0.00	0.12	0.67	0.00	0.78	1.00	0.55
$\langle D \rangle_{z,t}$: O	0.77	1.00	0.52	0.00	0.51	0.00	1.00	0.33
$\langle D \rangle_{z,t}$: C	0.69	0.00	0.50	1.00	0.09	0.00	1.00	0.43
$\langle D \rangle_{z,t}$: S	0.49	0.39	1.00	0.00	0.36	0.73	1.00	0.00
SUM	7.56	4.18	8.75	5.16	2.99	5.88	11.23	4.87

Figure 6. Ranking of the alternative city-block-design versions on a relative scale 0-1 based on *pc*, *Fp*, volume-averaged $\langle D \rangle_V$ and column-averaged dilution rate $\langle D \rangle_{z,t}$. B = boulevard, O = other street canyons, C = courtyards and S = surroundings. The bar plot illustrates the ranking only for street canyons (B and O). The colours in the bar plot correspond to the colours in the table.

Conclusions and outlook

The study originated from the need of urban planners to build healthy and comfortable neighbourhoods in Helsinki. The main aim was to investigate how the structural arrangement and orientation of perimeter blocks affect the ventilation and dispersion of traffic-related emissions under two contrasting meteorological conditions. The LES study is conducted over a highly realistic representation of an urban area in Helsinki and applies novel methods including two-way self-nesting and a Lagrangian particle model. The study concludes that the most effective way to improve pollutant ventilation and air quality within a densely built urban neighbourhood is to introduce variation in the perimeter block heights and to avoid long street canyons. The investigation reveals that the chosen city-block-design has a strong impact both on local concentrations and pollutant transport mechanisms. However, pollutant concentrations are clearly higher under stably stratified inflow conditions. The results of this study provide detailed information for urban planners on how design choices can reduce the level of pollution exposure in a densely built environment.

Here we simulated the transport and ventilation of passive tracers. However, chemical reactions and dynamic processes manipulating the concentrations should be included for reactive gases and aerosol particles. Furthermore, anthropogenic heat emissions and solar radiation were neglected in this study, which are likely to modify the flow patterns further.

References

Antoniu, N. et al. (2017). CFD and wind-tunnel analysis of outdoor ventilation in a real compact heterogeneous urban area: Evaluation using "air delay", *Build. Environ.* 126,355-372.

Buccolieri, R. et al. (2009). Aerodynamic effects of trees on pollutant concentration in street canyons. *Sci. Total Environ.* 407, 5247–5256.

European Environment Agency (2017). Air quality in Europe – 2017 report, EEA Report No 13/2017, Luxembourg: Publications Office of the European Union.

Gakidou, E., et al. (2017). Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016, *The Lancet*, 390, 1345–1422.

Gromke, C. and Blocken, B. (2015). Influence of avenue-trees on air quality at the urban neighborhood scale. Part II: Traffic pollutant concentrations at pedestrian level. *Environ. Pollut.*, 196, 176–184.

Hellsten, A. et al. (2017). Nested multi-scale system in the PALM large-eddy simulation model. In Proceedings of the 35th International Technical Meeting on Air Pollution Modelling and its Application, Chania, Crete, Greece, 3–7 October 2016; Springer: Cham, Switzerland.

Karagulian, F., et al. (2015). Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level, *Atmos. Environ.*, 120, 475 – 483.

Keck, M. et al. (2014). First Results of High Resolution Large-Eddy Simulations of the Atmospheric Boundary Layer. *J. Heat Island Inst. Int.* 9, 39–43.

Kurppa, M. (2016). Assessing pollutant ventilation in city planning alternatives using a large-eddy simulation (Master thesis), University of Helsinki, Helsinki, Finland.

Maronga, B. et al. (2015). The Parallelized Large-Eddy Simulation Model (PALM) version 4.0 for atmospheric and oceanic flows: Model formulation, recent developments, and future perspectives. *Geosci. Model Dev.*, 8, 2515–2551.

Nordbo, A. et al. (2015). Urban surface cover determined with airborne lidar at 2 m resolution–Implications for surface energy balance modelling. *Urban Clim.*, 13, 52–72.

Nosek, Š. et al. (2016). Ventilation Processes in a Three-Dimensional Street Canyon. *Bound. Layer Meteorol.*,159, 259–284.

Vuori, P. and Laakso, S. (2017). Population projection of Helsinki and the Helsinki Region in 2017-2050 (in Finnish), Helsinki: The Helsinki City Executive Office.

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This article draws on the recently published paper:

Kurppa M, A. Hellsten, M. Auvinen, T. Vesala, S. Raasch and L. Järvi (2018). Ventilation and Air Quality in City Blocks Using Large-Eddy Simulation – Urban Planning Perspective, *Atmosphere*, 9(2), 65 (doi: 10.3390/atmos9020065).

Ice in Dutch Cities

Figure 1. Skating in Dutch cities. *Hendrick Avercamp*, 1610

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The Dutch love ice-skating. Already many famous 17th century paintings visualized citizens skating on the Dutch canals. Figure 1 shows the painting "*Skating in a village*" by the painter Avercamp (1610), and shows the population skating in severe winter conditions. At that time apparently sufficient ice was forming on the canals within the cities, and it was not necessary to go to the larger lakes in the countryside. However, with the current-day warmer climate, and the omnipresent urbanization, resulting in an urban heat island effect of several degrees, it is clear conditions have changed. Nowadays the development of thick ice floors is rather scarce and develop differently between cities and the countryside, which will be illustrated for a recent frost episode in the Netherlands in the winter of 2018.

In this study we have quantified the difference in ice thickness in canals between the city and the countryside for a region around The Hague. Although the winter in general was rather mild, between February 24th and March 2nd the Netherlands were subject to a strong frost period with strong easterly winds (Figure 2). A cold air mass that was advected into the country resulted in low apparent temperatures, but also ice growth on the canals and ditches, though it was rather late in the season. On several days clouds appeared during the day, which prevented the ice floor from melting due to solar radiation.

To quantify the difference in ice thickness between cities and countryside, we utilize the ice thickness model formulated by De Bruin and Wessels (1988). The model solves the surface radiation and energy balance for an ice surface in a well-mixed lake or canal. The net radiation of the ice surface depends on the air temperature, humidity, wind speed and cloud cover. The ice grows from the surface and deepens into the underlying water. New ice forms at the bottom of the existing ice floor, which means that the released heat due to the phase change from water to ice has to be transported through the ice floor to the ice surface and to the atmosphere subsequently. The more ice has formed, the more heat conduction is reduced and ice growth is slowed down. On the other hand stronger turbulence due to high wind speeds will speed up the heat exchange from the ice surface to the atmosphere.

Here we have forecast the ice thickness in canals and ditches for the region around the city of The Hague in the west of the country, which also includes cities as Delft and Zoetermeer. The ice model has been driven by weather observations from the WMO station Rotterdam-The Hague airport, which is the closest WMO station but ~15 km away from The Hague itself. In order to account for urbanization we have utilized the diagnostic equation for the UHI as developed in Theeuwes et al (2017). Their method estimates the daily max UHI based on meteorological variables (daily mean incoming solar radiation, wind speed and the diurnal temperature range in the countryside) and urban morphological parameters (sky-view factor and vegetation fraction). The latter have recently been mapped at 100 m resolution. The daily maximum UHI has been interpolated to hourly values using the idealised diurnal UHI cycle in Oke (1982). In addition, we have added a simple SVF-based wind speed reduction and a moderate anthropogenic heat flux of 25 W/m^2 to the urban areas in the grid.

Figure 3 shows the modelled ice thickness for the study area at the end of the frost episode, i.e. March 2nd. In the countryside about 13 cm of ice was modelled. We find a clear and rather sharp contrast with the urban areas. There, the ice floors were substantially thinner, typically amounting to only 9-10 cm. In the central business district of the city center of the Hague the ice thickness is minimum. On the other hand, in the south of the Hague a rather open area still offers sufficient room for ice skating with an ice thickness of 13 cm. In reality the ice floors have been slightly less thick than forecast. The largest observed value from crowdsourced data amounted to 8 cm in the countryside. Despite the discrepancy with the observations, the presented map clearly shows the ice thickness potential for this frost episode, including the reduced ice in urban areas.

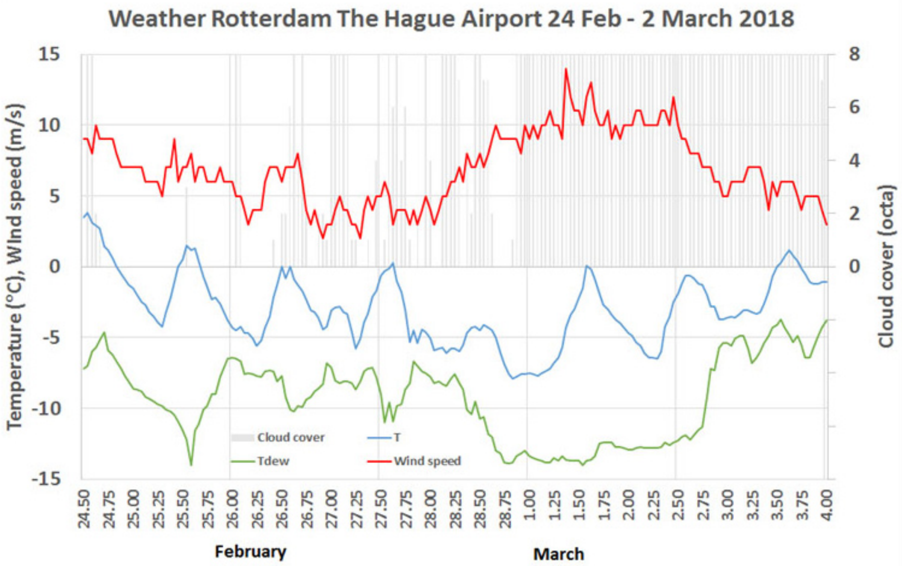

Figure 2. Observed temperature, dew point temperature, wind speed and cloud cover during 24 Feb – 2 March 2018 at the Rotterdam The Hague airport.

It is important to note that local conditions may deviate from the model forecasts since the ice model does not account for long-lived wakes in the water that can be maintained by the wind. In fact many of the big lakes in the study area had rather thin ice due to the high wind speeds. In addition, close proximity to the coast, local warm water pollution and water flow under the ice layer due to drainage will limit the ice extent. Also the model does not estimate the ice quality; the relatively low winds in cities may result in more smooth ice than the ice on larger lakes.

Acknowledgements: We thank KNMI for providing the gridded data for sky view factor and vegetation fraction in the study area.

References:

De Bruin, H.A. and H.R. Wessels, 1988: A Model for the Formation and Melting of Ice on Surface Waters. *J. Appl. Meteor.*, 27, 164–173.

Oke, T. R., 1982: The energetic basis of the urban heat island. *Quart. J. Roy. Meteor. Soc.*, 108, 1–24.

Theeuwes, N. E., Steeneveld, G. , Ronda, R. J. and Holtslag, A. A.M., 2017: A diagnostic equation for the daily maximum urban heat island effect for cities in northwestern Europe. *Int. J. Climatol.*, 37: 443-454.

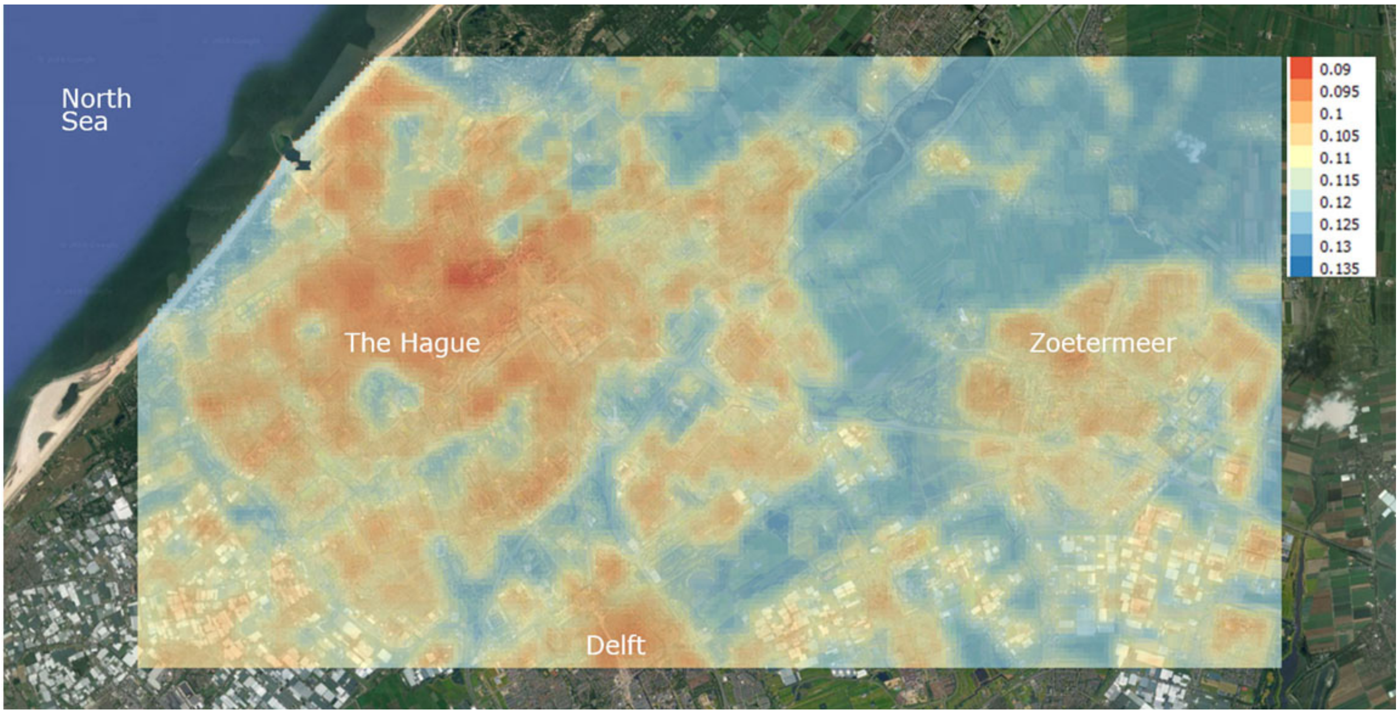

Figure 3. Spatial distribution of the forecast ice thickness for March 2nd in the region around The Hague (Netherlands).

Urban flow, dispersion and hydrology at the 98th Annual AMS meeting in Austin (TX), USA

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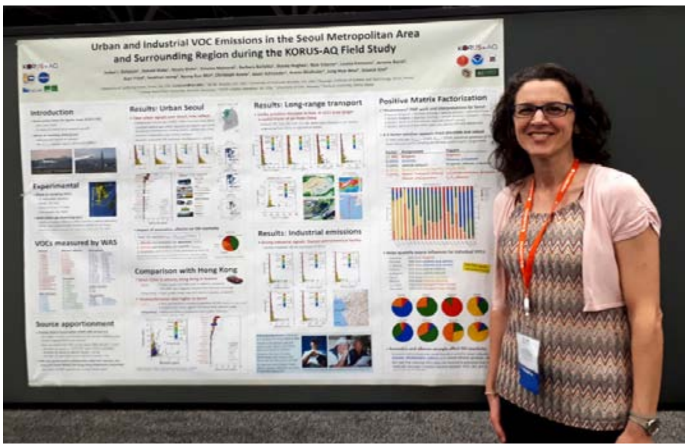
The 98th Annual Meeting of the American Meteorological Society was held in Austin (Texas) from 7 to 11 January 2018. With more than 4,000 attendees from across the world and more than 2,100 oral and 1,200 poster presentations this was a very successful meeting.

Research on urban flow, dispersion, air quality and the micro-climate was presented in several sessions at the *20th Joint Conference on the Applications of Air Pollution Meteorology with the A&WMA*, in part jointly hosted by the AMS Committee on Meteorological Aspects of Air Pollution (CMAAP) and the AMS Board on the Urban Environment.

Regarding emerging technologies in atmospheric dispersion and air quality modelling, **Paul Bieringer** (Aeris LLC, USA) demonstrated the great prospects of conducting computationally demanding large-eddy simulations on GPUs, achieving computational speed-ups that could eventually pave the way for using turbulence-resolving methods for near real-time dispersion predictions in cities. **Maider Llaguno-Munitxa** (Princeton Univ., USA) presented an innovative approach to provide weather and air quality data from autonomous sensing kits deployed onto private cars or public transportation to the public using mobile apps that apply augmented reality visualisation techniques. **Chenghao Wang** (Arizona State Univ., USA) presented a new model for estimating source areas of fluxes and concentrations based on a backward Lagrangian stochastic footprint model.

Austin skyline as seen from the Annual Meeting's conference venue.



Isobel J. Simpson (Univ. of California, Irvine) presented her study on urban and industrial VOC emissions in the Seoul metropolitan area based on aircraft measurements.

Another focus was put on the improvement of models through measurements. **Ron L. Petersen** (CPP Inc., USA) presented recent improvements to the building downwash algorithm in the AERMOD dispersion model based on comprehensive wind-tunnel datasets. **Steven Hanna** (Hanna Consultants, USA) discussed results from the Jack Rabbit II chlorine release experiment carried out in a 'mock urban' array of about 80 shipping containers in the Utahan desert, which can be used to assess heavy-gas dispersion models. **Isobel J. Simpson** (Univ. of California, Irvine, USA) explored aircraft measurements of VOC concentrations above Seoul with the aim to assess emission inventories. Further presentations highlighted the effects of tall buildings on urban flow and dispersion and modelling challenges on local and city scales. Based on wind-tunnel measurements in a scale model of a part of central London, **Denise Hertwig** (Univ. of Reading, UK) showed that the strong interaction between the tall-building wake and the flow in the canopy layer cannot be described by classic conceptual models of urban flow. If pollutants are released at street level in the vicinity of a tall building, flow divergence and convergence in the canopy layer can lead to a displacement of the effective source location as shown in recent experiments and CFD simulation carried out in the DIPLOS project (www.diplos.org; "Dispersion of localised releases in a street network").

A special session focused on research from the ongoing Horizon 2020 project iSCAPE "Improving the smart control of air pollution in Europe" (www.iscapeproject.eu) involving several research groups across Europe. **K.V. Abhijith** (Global Centre for Clean Air Research, University of Surrey, UK) kicked-off the session by presenting an experimental case study for iSCAPE at sites in Guildford (UK), showing that pollutant exposure can be notably reduced by the presence of green vegetation barriers under cross-wind conditions. **Kirsti Jylhä** (Finnish Meteorological Institute) discussed the environmental and socio-economic benefits of green infrastructure in a Finnish city. Based on summer-time measurements in vegetated and non-vegetated street canyons in Bologna, **Francesco Barbano** (Univ. of Bologna, Italy) demonstrated that the effects of trees on air quality in street canyons depend strongly on the interaction between synoptic meteorological conditions, wind stress at roof-level, vertical stability and canyon geometry. CFD simulations of the Bologna case study presented by **Federico Prandini** (Univ. of Bologna, Italy) showed that the pollutant ventilation potential is mainly controlled by the street topology. **Silvana Di Sabatino** (Univ. of Bologna, Italy) discussed effects of mechanically and thermally driven street-canyon circulations on local temperatures and showed that the intensity of the UHI in Bologna, which is typically of the order of 7°C , depicts a spatial distribution with differences of 2–3°C within 1–2 km.

Session chaired by Jon Pleim, US EPA, who at the annual meeting received the award of the AMS Committee on Meteorological Aspects of Air Pollution (CMAAP) in acknowledgement of his outstanding contributions to the field.:

The *32nd Conference on Hydrology* hosted a further urban-focused session on the local and regional response of the water cycle due to urbanisation. Three talks from the University of Georgia (USA) explored characteristics of the urban enhancement of precipitation. **Neil Debbage** discussed the urban impact on precipitation and runoff during the 2009 flood event in Atlanta. **J. Marshall Shepherd** showed that statistically significant anomalies in rainfall patterns over and downwind of Atlanta are most evident in the early eve-

Members of the Horizon 2020 iSCAPE project (left to right): Francesco Barbano, Silvana Di Sabatino, Kirsti Jylhä, Federico Prandini and K.V. Abhijith.

ning hours. **Bradford Johnson** presented a study on the sensitivity of surface precipitation type in winter in response to urban areas based on simulations with WRF. **Elie Bou-Zeid's** (Princeton Univ., USA) talk focused on hydrological determents of temperature extremes in cities and provided a summary of open challenges for urban surface representations in atmospheric and hydrological models. **Simone Kotthaus'** (Univ. of Reading, UK) contribution summarised details of a new algorithm ('CABAM') to characterise the atmospheric boundary layer based on automatic LIDAR and ceilometer measurements, which was successfully evaluated against long-term measurements in central London, UK.

Some of the oral presentations have been recorded and can now be found on the meeting website: https://annual.ametsoc.org/2018/.

Exhibitors showcasing their products and services at the meeting.

CitiesIPCC in Edmonton turns the spotlight on urban areas

The first IPCC-approved conference focusing on cities sets an agenda for recognizing the role of urbanization in future climate change assessment reports

By James Voogt and Winston Chow

On March 4–7, the **CitiesIPCC** conference was held in Edmonton, Alberta. This first-of-its-kind conference was intended to inspire the next frontier of research focused on assessing the current state of cities and climate change. The primary goal of the conference is to assess the state of academic and practice-based knowledge pertaining to cities and climate change, and to establish a global research agenda based on the joint identification of key gaps by the academic, practitioner and urban policy-making communities.

Of interest is that the conference was approved by the Intergovernmental Panel on Climate Change (IPCC), and co-organised by a very wide range of organizations including UN-Habitat, UN Environment (UNEP), Cities Alliance, ICLEI – Local Governments for Sustainability, Future Earth, the Sustainable Development Solutions Network (SDSN) and United Cities and Local Governments (UCLG). The ultimate aim of the conference is to generate information and set the agenda for a greater focus on urban areas in future IPCC Assessment Report Cycles; starting from sixth (AR6) this year, and culminating in a Special Report on Cities and Climate Change that will be published as part of the seventh (AR7) cycle from 2023.

The conference was held in the Canadian city of Edmonton at the Shaw Conference Centre along the banks of the North Saskatchewan River in downtown Edmonton. Edmonton was an interesting choice of conference location given that, firstly, the weather during the conference was bitterly cold for many delegates (it was -22ºC on the first morning, which made the walk to the venue a rather interesting one for a correspondent based in tropical climes!); second, this is 'fossil fuel' country – Edmonton is located in the province of Alberta, a major producer of oil and gas, and serves as the gateway to northern Alberta which is home to major oil sands development. At the time of conference opening, an inter-provincial dispute between Alberta and the neighbouring province of British Columbia over increased transport of Alberta oil by a pipeline over the Rocky Mountains to a port in the Greater Vancouver area had been receiving significant media attention.

But the (relatively) more progressive provincial government in Alberta has recently put a price on carbon, is in the process of phasing out coal for electricity generation and is implementing a number of initiatives to help home owners improve energy efficiency. And Edmonton's Mayor, Don Iveson, is a young, dynamic and popular civic leader who has made climate change and energy leadership one of his important policy objectives. His views on Cities and Climate Leadership and his opening remarks at the conference, suggest he is a mayor who 'gets it' and understands that bottom-up action in cities, combined with leveraging efforts from other levels of government, are important to making progress on climate change. The appearance of major political office holders at the municipal, provincial and federal level at the conference signified the importance the event had been given by all levels of government.

The conference agenda was centred on 3 days, with a fourth day for fieldtrips within the city that showcased tangible evidence of Edmonton's climate change initiatives. In total, there were 800 attendees that included government leaders, climate scientists, policy researchers, policy-makers, policy influencers, city planners and technical experts from across the globe. Interest in the conference was high as reportedly the number of session proposals received by the organizers was much larger than the available number of session slots (35). The conference was clearly well supported by the various levels of government – there were no registration costs for invited delegates, and both breakfast and lunch was catered for. To help attendees cope with the local climate, toques were provided as part of the conference package – a first for both of us. The event was also well staffed – both correspondents are pretty certain we've not been to a conference with as many dedicated student volunteers!

The conference was organized using a combination of key morning and evening plenaries that were sandwiched by parallel sessions (seven in total). These plenaries were livestreamed on social media, and were archived (available here). The chief moderator throughout all plenaries was David Miller, C40 Regional Director, North America and C40 Ambassador for Inclusive Climate Action who was previously both Mayor of the City of Toronto and C40 Chair. The plenaries usually involved multiple short invited presentations, followed by a moderated panel discussion involving different members; not just prominent academics, but important stakeholders such as practitioners and elected officials.

Questions from the floor or from Twitter were taken towards the end of the panel discussion. This format was also popular within individual sessions in the parallel streams and was likely a product of the organizers desire to "seek sessions with innovative formats to help foster the delivery of the unique conference objectives" and their requirement that sessions "incorporate a clear and visible element of knowledge exchange or co-generation among the scientific community and the practitioner and/or policy-making communities." While ambitious, and having some teething difficulties e.g. in selecting Twitterati questions, this format seemed to be a qualified success in practice particularly in the variety of questions that weren't restricted to purely science-based in theme (but which according to IPCC rules exclude questions of a political nature).

View of the planned Blatchford residential community (the current open space) that is developed from the former Edmonton International Airport.

IAUC affiliated delegates (left to right): Winston Chow, Nigel Tapper, James Voogt and Benedicte Dousset.

The sessions were organized around four themes that were treated sequentially through the conference:

Theme 1: Cities & climate change (Imperatives for action); in which local, regional and global scale action and commitments can set developmental agendas towards responding to the risks of climate change. These agendas incorporate multi-scale linkages between scientific research, with translating the academic information towards urban stakeholders, and effecting changes in behavior towards the aim of decarbonisation.

Theme 2: Urban emissions, impacts and vulnerabilities (Science and practice of cities); the focus was on how co-ordination and partnerships between agencies, practitioners, scientists and relevant stakeholders can effect reductions in urban exposure towards these emissions, impacts and vulnerabilities.

Theme 3: Solutions for the transition to low carbon and climate resilient cities (Science and practice for cities); Sessions and the plenary related to this theme dealt with approaches integrating nature with urban landscapes in order to increase urban resilience; much attention was placed in the emergence of disruptive technologies in cities e.g. autonomous cars, "smart" cities and the application of Big Data.

Theme 4: Enabling transformative climate action in cities (advancing science and advancing cities); Much attention was placed on how formal and informal sectors of cities – though a largely socio-economic and cultural perspectives – can find a roadmap towards keeping to emission pathways aspired to from the 2015 Paris Agreement.

IAUC affiliated delegates in the atrium of Roger's Place at the conference dinner.

Parallel/Breakout session topics were wide-ranging, and were more reflective of the type of content at UN Habitat III than of typical urban climate science conferences. These sessions covered topics such as climate justice, climate finance, governance issues, smart cities, energy systems, health, and policy. But all 4 themes included sessions with topics of interest to IAUC members. A sampling of some that we attended included: Urban Heat Island Effect and Climate Change in Cities, Urban Climate Information to Support Decision Making: From Local to Global, and Initiating Climate Awareness in Urban Planning Practices Through Participatory Action Research. Furthermore, several IAUC members actively participated in sessions through convening or giving oral and poster presentations e.g., **Nigel Tapper**, **Rafiq Hamdi**, **Edward Ng, Benedicte Dousset**, **Alexander Baklanov**, **Julia Hidalgo**, **Evyatar Erell**, **Valéry Masson**, **Chao Ren**, and your correspondents.

The final day of the conference was for delegates to take part in urban sustainability tours and field trips that took place away from the conference venue. Up to two tours (one in the morning, one after lunch) could be registered for, and I (WC) went for one showcasing the planning and design of the Blatchford district that involved converting the old international airport north of Edmonton's downtown into an ambitious sustainable, low-carbon residential area.

A number of background papers were developed by the CitiesIPCC Scientific Steering Committee to inform the conference discussions. Among these (for a full list and to access the papers see here) were Urban Climate Change Science, Impacts and Vulnerabilities: State-of-the-Art Findings and Key Research Gaps by Cynthia Rosenzweig et al., Urban Data Science for Global Climate Solutions by Felix Creutzig et al., and Towards a Novel Assessment Framework for Cities and Climate Change William Solecki et al. that may be of interest to IAUC members.

Also featured was presentation of the recent commentary in Nature by Bai et al. 'Six research priorities for cities and climate change'. Among the priorities are calls for developing remote sensing methodologies for monitoring dense urban fabrics, a global network of 'urban observatories, better understanding of climate interactions, incorporation of cities in climate modeling, and knowledge on "how urban morphologies, building materials and human activities affect atmospheric circulation, heat and light radiation, urban energy and water budgets". We are certain that these challenges are familiar to many IAUC members, but one of my (JV) lingering concerns from CitiesIPCC is the extent to which the field of urban climate science has been understood by those who have perhaps come at the problem from a larger scale perspective. But overall, CitiesIPCC provided us with a valuable experience as urban climate scientists to participate in a conference with the broader context of cities and climate change that will help set the agenda for future IPCC reports and which may help frame the important contributions that urban climate science can bring to this critical issue of our time.

Recent Urban Climate Publications

Afshari A (2017) A new model of urban cooling demand and heat island application to vertical greenery systems (VGS). *Energy and Buildings* 157:204 - 217.

Afshari A, Friedrich LA (2017) Inverse modeling of the urban energy system using hourly electricity demand and weather measurements, Part 1: Black-box model. *Energy and Buildings* 157:126 - 138.

Afshari A, Liu N (2017) Inverse modeling of the urban energy system using hourly electricity demand and weather measurements, Part 2: Gray-box model. *Energy and Buildings* 157:139 - 156.

Ahn K-H, Steinschneider S (2018) Time-varying suspended sediment-discharge rating curves to estimate climate impacts on fluvial sediment transport. *Hydrological Processes* 32:102-117.

Ai ZT, Mak CM (2018) Wind-induced single-sided natural ventilation in buildings near a long street canyon: CFD evaluation of street configuration and envelope design. *Journal of Wind Engineering and Industrial Aerodynamics* 172:96–106.

Alberti L, Colombo L, Formentin G (2018) Null-space Monte Carlo particle tracking to assess groundwater PCE (Tetrachloroethene) diffuse pollution in north-eastern Milan functional urban area. *Science of The Total Environment* 621:326-339.

Alizadeh-Choobari O, Najafi MS (2018) Extreme weather events in Iran under a changing climate. *Climate Dynamics* 50:249-260.

Allen MA, Voogt JA, Christen A (2018) Time-Continuous Hemispherical Urban Surface Temperatures. *Remote Sensing* 10:

Alvizuri J, Cataldo J, Smalls-Mantey LA, Montalto FA (2017) Green roof thermal buffering: Insights derived from fixed and portable monitoring equipment. *Energy and Buildings* 151:455 - 468.

Andersson JC, Arheimer B, TraorÃ© F, Gustafsson D, Ali A (2017) Process refinements improve a hydrological model concept applied to the Niger River basin. *Hydrological Processes* 31:4540-4554.

Anting N, Din MFM, Iwao K, Ponraj M, Siang AJLM, Yong LY, Prasetijo J (2018) Optimizing of near infrared region reflectance of mix-waste tile aggregate as coating material for cool pavement with surface temperature measurement. *Energy and Buildings* 158:172 - 180.

Arsiso BK, Tsidu GM, Stoffberg GH, Tadesse T (2018) Influence of urbanization-driven land use/cover change on climate: The case of Addis Ababa, Ethiopia. *Physics and Chemistry of the Earth, Parts A/B/C*

In this edition is a list of publications that have come out between **December 2017 and February 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**.

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,

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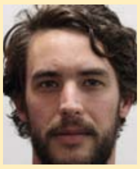
The Bibliography Committee


Lilly Rose Amirtham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Lech Gawuc


Rafiq Hamdi


Julia Hidalgo


Martina Petralli


Iara Santos


Abel Tablada


Marie-Leen Verdonck


Hendrik Wouters

Ascott MJ, Marchant BP, Macdonald D, McKenzie AA, Bloomfield JP (2017) Improved understanding of spatio-temporal controls on regional scale groundwater flooding using hydrograph analysis and impulse response functions. *Hydrological Processes* 31:4586-4599.

Babaei S, Ghazavi R, Erfanian M (2018) Urban flood simulation and prioritization of critical urban sub-catchments using SWMM model and PROMETHEE II approach. *Physics and Chemistry of the Earth, Parts A/B/C*

Baklanov A, Grimmond CSB, Carlson D, Terblanche D, Tang X, Bouchet V, Lee B, Langendijk G, Kolli RK, Hovsepyan A (2018) From urban meteorology, climate and environment research to integrated city services. *Urban Climate* 23:330 - 341.

Bevilacqua P, Mazzeo D, Bruno R, Arcuri N (2017) Surface temperature analysis of an extensive green roof for the mitigation of urban heat island in southern mediterranean climate. *Energy and Buildings* 150:318 - 327.

Bian T, Ren GY, Yue YX (2017) Effect of Urbanization on Land-Surface Temperature at an Urban Climate Station in North China. *Boundary-layer Meteorology* 165:553–567.

Bjorkegren A, Grimmond CSB (2018) Net carbon dioxide emissions from central London. *Urban Climate* 23:131 - 158.

Booth DB, Konrad CP (2017) Hydrologic metrics for status-and-trends monitoring in urban and urbanizing watersheds. *Hydrological Processes* 31:4507-4519.

Broadbent AM, Coutts AM, Tapper NJ, Demuzere M (2018) The cooling effect of irrigation on urban microclimate during heatwave conditions. *Urban Climate* 23:309 - 329.

Castaneda A, Corvo F, Howland JJ, Marrero R (2018) Penetration of marine aerosol in a tropical coastal city: Havana. *Atmosfera* 31:87-104.

Cerezo C, Sokol J, AlKhaled S, Reinhart C, Al-Mumin A, Hajiah A (2017) Comparison of four building archetype characterization methods in urban building energy modeling (UBEM): A residential case study in Kuwait City. *Energy and Buildings* 154:321 - 334.

Chen S, Hu D (2017) Parameterizing Anthropogenic Heat Flux with an Energy-Consumption Inventory and Multi-Source Remote Sensing Data. *Remote Sensing* 9:

Conticelli E, Proli S, Tondelli S (2017) Integrating energy efficiency and urban densification policies: Two Italian case studies. *Energy and Buildings* 155:308 - 323.

Czajkowski J, Engel V, Martinez C, Mirchi A, Watkins D, Sukop MC, Hughes JD (2018) Economic impacts of urban flooding in South Florida: Potential consequences of managing groundwater to prevent salt water intrusion. *Science of The Total Environment* 621:465-478.

Daniel M, Lemonsu A, Viguie V (2018) Role of watering practices in large-scale urban planning strategies to face the heat-wave risk in future climate. *Urban Climate* 23:287 - 308.

Dey S, Gupta S, Chakraborty A, Sibanda P (2018) Influences of boundary layer phenomena and meteorology on ambient air quality status of an urban area in eastern India. *Atmosfera* 31:69-86.

Djedjig R, Belarbi R, Bozonnet E (2017) Experimental study of green walls impacts on buildings in summer and winter under an oceanic climate. *Energy and Buildings* 150:403 - 411.

Djekic J, Djukic A, Vukmirovic M, Djekic P, Brankovic MD (2018) Thermal comfort of pedestrian spaces and the influence of pavement materials on warming up during summer. *Energy and Buildings* 159:474 - 485.

Dong L, Mitra C, Greer S, Burt E (2018) The Dynamical Linkage of Atmospheric Blocking to Drought, Heatwave and Urban Heat Island in Southeastern US: A Multi-Scale Case Study. *Atmosphere* 9:

Dyce DR, Voogt JA (2018) The influence of tree crowns on urban thermal effective anisotropy. *Urban Climate* 23:91 - 113.

Eastin MD, Baber M, Boucher A, Bari SD, Hubler R, Stimac-Spalding B, Winesett T (2018) Temporal Variability of the Charlotte (Sub)Urban Heat Island. *Journal of Applied Meteorology and Climatology* 57:81-102.

Efthimiou GC, Andronopoulos S, Bartzis JG (2018) Prediction of dosage-based parameters from the puff dispersion of airborne materials in urban environments using the CFD-RANS methodology. *Meteorology and Atmospheric Physics* 130:107–124.

Eger CG, Chandler DG, Driscoll CT (2017) Hydrologic processes that govern stormwater infrastructure behaviour. *Hydrological Processes* 31:4492-4506.

Emmanuel R (2018) Performance standard for tropical outdoors: A critique of current impasse and a proposal for way forward. *Urban Climate* 23:250 - 259.

Fahmy M, El-Hady H, Mahdy M, Abdelalim MF (2017) On the green adaptation of urban developments in Egypt; predicting community future energy efficiency using coupled outdoor-indoor simulations. *Energy and Buildings* 153:241 - 261.

Fan Y, Li Y, Hang J, Wang K (2017) Diurnal variation of natural convective wall flows and the resulting air change rate in a homogeneous urban canopy layer. *Energy and Buildings* 153:201 - 208.

de Faria Peres L, de Lucena AJ, Rotunno Filho OC, de Almeida Franca JR (2018) The urban heat island in Rio de Janeiro, Brazil, in the last 30 years using remote sensing data. *International Journal of Applied Earth Observation and Geoinformation* 64:104-116.

Forestieri A, Arnone E, Blenkinsop S, Candela A, Fowler H, Noto LV (2018) The impact of climate change on extreme precipitation in Sicily, Italy. *Hydrological Processes* 32:332-348.

Fox DM, Carrega P, Ren Y, Caillouet P, Bouillon C, Robert S (2018) How wildfire risk is related to urban planning and Fire Weather Index in SE France (1990-2013). *Science of The Total Environment* 621:120-129.

Funari V, Mantovani L, Vigliotti L, Tribaudino M, Dinelli E, Braga R (2018) Superparamagnetic iron oxides nanoparticles from municipal solid waste incinerators. *Science of The Total Environment* 621:687-696.

Gao M, Shen H, Han X, Li H, Zhang L (2017) Multiple timescale analysis of the urban heat island effect based on the Community Land Model: a case study of the city of Xi>an, China. Environmental *Monitoring and Assessment* 190:8.

Gao Z, Bresson R, Qu Y, Milliez M, de Munck C, Carissimo B (2018) High resolution unsteady RANS simulation of wind, thermal effects and pollution dispersion for studying urban renewal scenarios in a neighborhood of Toulouse. *Urban Climate* 23:114 - 130.

Gilbert HE, Rosado PJ, Ban-Weiss G, Harvey JT, Li H, Mandel BH, Millstein D, Mohegh A, Saboori A, Levinson RM (2017) Energy and environmental consequences of a cool pavement campaign. *Energy and Buildings* 157:53 - 77.

Gobakis K, Kolokotsa D (2017) Coupling building energy simulation software with microclimatic simulation for the evaluation of the impact of urban outdoor conditions on the energy consumption and indoor environmental quality. *Energy and Buildings* 157:101 - 115.

Golasi I, Salata F, de Lieto Vollaro E, Coppi M (2018) Complying with the demand of standardization in outdoor thermal comfort: a first approach to the Global Outdoor Comfort Index (GOCI). *Building and Environment* 130:104 - 119.

Goldblatt R, Stuhlmacher MF, Tellman B, Clinton N, Hanson G, Georgescu M, Wang C, Serrano-Candela F, Khandelwal AK, Cheng WH, Balling RCJ (2018) Using Landsat and nighttime lights for supervised pixel-based image classification of urban land cover. *Remote Sensing Of Environment* 205:253-275.

Golkar F, Sabziparvar A. A.and Khanbilvardi R, Nazemosadat MJ, Zand-Parsa S, Rezaei Y (2018) Estimation of instantaneous air temperature using remote sensing data. *International Journal Of Remote Sensing* 39:258-275.

Guattari C, Evangelisti L, Balaras CA (2018) On the assessment of urban heat island phenomenon and its effects on building energy performance: A case study of Rome (Italy). *Energy and Buildings* 158:605 - 615.

Guo Z, Brusseau ML (2017) The impact of well-field configuration on contaminant mass removal and plume persistence for homogeneous versus layered systems. *Hydrological Processes* 31:4748-4756.

Han B-S, Park S-B, Baik J-J, Park J, Kwak K-H (2017) Large-eddy simulation of vortex streets and pollutant dispersion behind high-rise buildings. *Quarterly Journal of the Royal Meteorological Society* 143:2714–2726.

Heidarinejad M, Mattise N, Dahlhausen M, Sharma K, Benne K, Macumber D, Brackney L, Srebric J (2017) Demonstration of reduced-order urban scale building energy models. *Energy and Buildings* 156:17 - 28.

Hernandez IER, Shi W (2018) A Random Forests classification method for urban land-use mapping integrating spatial metrics and texture analysis. *International Journal of Remote Sensing* 39:1175-1198.

Heusinger J, Sailor DJ, Weber S (2018) Modeling the reduction of urban excess heat by green roofs with respect to different irrigation scenarios. *Building and Environment* 131:174 - 183.

Heusinkveld BG, Sterenborg G, Steeneveld GJ, Attema JJ, Ronda RJ, Holtslag AAM (2017) Smartphone App Brings Human Thermal Comfort Forecast in Your Hands. *Bulletin of the American Meteorological Society* 98:2533-2541.

Ho HC, Lau KK-L, Ren C, Ng E (2017) Characterizing prolonged heat effects on mortality in a sub-tropical high-density city, Hong Kong. *International Journal of Biometeorology* 61:1935–1944.

Hooyberghs H, Verbeke S, Lauwaet D, Costa H, Floater G, De Ridder K (2017) Influence of climate change on summer cooling costs and heat stress in urban office buildings. *Climatic Change* 144:721–735.

Hu ZX, Cui GX, Zhang ZS (2018) Numerical study of mixed convective heat transfer coefficients for building cluster. *Journal of Wind Engineering and Industrial Aerodynamics* 172:170–180.

Huang B, Xing K, Pullen S (2017) Carbon assessment for urban precincts: Integrated model and case studies. *Energy and Buildings* 153:111 - 125.

Huang K-T, Li Y-J (2017) Impact of street canyon typology on building and peak cooling energy demand: A parametric analysis using orthogonal experiment. *Energy and Buildings* 154:448 - 464.

Hwang R-L, Lin C-Y, Huang K-T (2017) Spatial and temporal analysis of urban heat island and global warming on residential thermal comfort and cooling energy in Taiwan. *Energy and Buildings* 152:804 - 812.

Ichinose M, Inoue T, Nagahama T (2017) Effect of retro-reflecting transparent window on anthropogenic urban heat balance. *Energy and Buildings* 157:157 - 165.

Ikegaya N, Ikeda Y, Hagishima A, Tanimoto J (2017) Evaluation of rare velocity at a pedestrian level due to turbulence in a neutrally stable shear flow over simplified urban arrays. *Journal of Wind Engineering and Industrial Aerodynamics* 171:137–147.

Irmak MA, Yilmaz S, Dursun D (2017) Effect of different pavements on human thermal comfort conditions. *Atmosfera* 30:355-366.

Jain M, Dimri AP, Niyogi D (2017) Land-Air Interactions over Urban-Rural Transects Using Satellite Observations: Analysis over Delhi, India from 1991-2016. *Remote Sensing* 9:

Kaenchan P, Guinée J, Gheewala SH (2018) Assessment of ecosystem productivity damage due to land use. *Science of The Total Environment* 621:1320-1329.

Karakounos I, Dimoudi A, Zoras S (2018) The influence of bioclimatic urban redevelopment on outdoor thermal comfort. *Energy and Buildings* 158:1266 - 1274.

Klok EJL, Kluck JJ (2018) Reasons to adapt to urban heat (in the Netherlands). *Urban Climate* 23:342 - 351.

Kokkonen TV, Grimmond CSB, Raty O, Ward HC, Christen A, Oke T. R and. Kotthaus S, Jarvi L (2018) Sensitivity of Surface Urban Energy and Water Balance Scheme (SUEWS) to downscaling of reanalysis forcing data. *Urban Climate* 23:36 - 52.

Kotharkar R, Bagade A (2018) Evaluating urban heat island in the critical local climate zones of an Indian city. *Landscape and Urban Planning* 169:92 - 104.

Koura J, Manneh R, Belarbi R, Khoury VE, Bachawati ME (2017) Seasonal variability of temperature profiles of vegetative and traditional gravel-ballasted roofs: A case study for Lebanon. *Energy and Buildings* 151:358 - 364.

Krüger E, Rossi F, Drach P (2017) Calibration of the physiological equivalent temperature index for three different climatic regions. *International Journal of Biometeorology* 61:1323–1336.

Lai D, Zhou X, Chen Q (2017) Measurements and predictions of the skin temperature of human subjects on outdoor environment. *Energy and Buildings* 151:476 - 486.

Lam CKC, Gallant AJE, Tapper NJ (2018) Perceptions of thermal comfort in heatwave and non-heatwave conditions in Melbourne, Australia. *Urban Climate* 23:204 - 218.

Lamarca C, Quense J, HenrÃ¬quez C (2018) Thermal comfort and urban canyons morphology in coastal temperate climate, Concepcion, Chile. *Urban Climate* 23:159 - 172.

Lau G, Ngan K (2018) Analysing urban ventilation in building arrays with the age spectrum and mean age of pollutants. *Building and Environment* 131:288 - 305.

Lenzholzer S, Klemm W, Vasilikou C (2018) Qualitative methods to explore thermo-spatial perception in outdoor urban spaces. *Urban Climate* 23:231 - 249.

Li C, Song Y, Kaza N (2018) Urban form and household electricity consumption: A multilevel study. *Energy and Buildings* 158:181 - 193.

Li H, Cui X, Zhang D-L (2017) Sensitivity of the initiation of an isolated thunderstorm over the Beijing metropolitan region to urbanization, terrain morphology and cold outflows. *Quarterly Journal of the Royal Meteorological Society* 143:3153–3164.

Li X, Mitra C, Dong L, Yang Q (2018) Understanding land use change impacts on microclimate using Weather Research and Forecasting (WRF) model. *Physics and Chemistry of the Earth, Parts A/B/C* 103:115-126.

Li X, Ratti C, Seiferling I (2018) Quantifying the shade provision of street trees in urban landscape: A case study in Boston, USA, using Google Street View. *Landscape and Urban Planning* 169:81 - 91.

Lim TK, Ignatius M, Miguel M, Wong NH, Juang H-MH (2017) Multi-scale urban system modeling for sustainable planning and design. *Energy and Buildings* 157:78 - 91.

Lin F-Y, Lin T-P, Hwang R-L (2017) Using geospatial information and building energy simulation to construct urban residential energy use map with high resolution for Taiwan cities. *Energy and Buildings* 157:166 - 175.

Lin P, Lau SSY, Qin H, Gou Z (2017) Effects of urban planning indicators on urban heat island: a case study of pocket parks in high-rise high-density environment. *Landscape and Urban Planning* 168:48 - 60.

Lin T-P, Lin F-Y, Wu P-R, Hammerle M, HÃ¶fle B, Bechtold S, Hwang R-L, Chen Y-C (2017) Multiscale analysis and reduction measures of urban carbon dioxide budget based on building energy consumption. *Energy and Buildings* 153:356 - 367.

Liu F, Kang J (2018) Relationship between street scale and subjective assessment of audio-visual environment comfort based on 3D virtual reality and dual-channel acoustic tests. *Building and Environment* 129:35 - 45.

Liu J, Xiong Y, Wang Y, Luo T (2018) Soundscape effects on visiting experience in city park: A case study in Fuzhou, China. *Urban Forestry & Urban Greening* 31:38-47.

Liu Z, Zheng C, Wu Y, Song Y (2018) Investigation on characteristics of thousand-meter height wind profiles at non-tropical cyclone prone areas based on field measurement. *Building and Environment* 130:62 - 73.

Lokoshchenko MA (2017) Urban Heat Island and Urban Dry Island in Moscow and Their Centennial Changes. *Journal of Applied Meteorology and Climatology* 56:2729-2745.

Luo K, Hu X, He Q, Wu Z, Cheng H, Hu Z, Mazumder A (2018) Impacts of rapid urbanization on the water quality and macroinvertebrate communities of streams: A case study in Liangjiang New Area, China. *Science of The Total Environment* 621:1601-1614.

Mariani Z, Dehghan A, Joe P, Sills D (2018) Observations of Lake-Breeze Events During the Toronto 2015 Pan-American Games. *Boundary-Layer Meteorology* 166:113–135.

Martin M, Wong NH, Hii DJC, Ignatius M (2017) Comparison between simplified and detailed EnergyPlus models coupled with an urban canopy model. *Energy and Buildings* 157:116 - 125.

Mathew A, Khandelwal S, Kaul N (2018) Analysis of diurnal surface temperature variations for the assessment of surface urban heat island effect over Indian cities. *Energy and Buildings* 159:271 - 295.

Matthias V, Aulinger A, Bieser J, Chen Y, Geyer B, Gao J, Quante M, Zhang F (2017) Modeling high aerosol loads in China in January 2013. *Urban Climate* 22:35 - 50.

Mei S-J, Hu J-T, Liu D, Zhao F-Y, Li Y, Wang H-Q (2018) Thermal buoyancy driven canyon airflows inside the compact urban blocks saturated with very weak synoptic wind: Plume merging mechanism. *Building and Environment* 131:32 - 43.

Mei S-J, Hu J-T, Liu D, Zhao F-Y, Li Y, Wang Y, Wang H-Q (2017) Wind driven natural ventilation in the idealized building block arrays with multiple urban morphologies and unique package building density. *Energy and Buildings* 155:324 - 338.

Menzer O, McFadden JP (2017) Statistical partitioning of a three-year time series of direct urban net CO2 flux measurements into biogenic and anthropogenic components. *Atmospheric Environment* 170:319 - 333.

Mexia T, Vieira J, Principe A, Anjos A, Silva P, Lopes N, Freitas C, Santos-Reis M, Correia O, Branquinho C, Pinho P (2018) Ecosystem services: Urban parks under a magnifying glass. *Environmental Research* 160:469-478.

Miglani S, Orehounig K, Carmeliet J (2018) A methodology to calculate long-term shallow geothermal energy potential for an urban neighbourhood. *Energy and Buildings* 159:462 - 473.

Mohapatra GN, Rakesh V, Ramesh KV (2017) Urban extreme rainfall events: categorical skill of WRF model simulations for localized and non-localized events. *Quarterly Journal of the Royal Meteorological Society* 143:2340–2351.

Monnier B, Goudarzi S. A. Vinuesa R, Wark C (2018) Turbulent Structure of a Simplified Urban Fluid Flow Studied Through Stereoscopic Particle Image Velocimetry. *Boundary-Layer Meteorology* 166:239–268.

Monteiro CS, Costa C, Pina A, Santos MY, Ferrao P (2018) An urban building database (UBD) supporting a smart city information system. *Energy and Buildings* 158:244 - 260.

Morabito M, Crisci A, Georgiadis T, Orlandini S, Munafo M, Congedo L, Rota P, Zazzi M (2018) Urban Imperviousness Effects on Summer Surface Temperatures Nearby Residential Buildings in Different Urban Zones of Parma. *Remote Sensing* 10:

Morini E, Castellani B, De Ciantis S, Anderini E, Rossi F (2018) Planning for cooler urban canyons: Comparative analysis of the influence of facades reflective properties on urban canyon thermal behavior. *Solar Energy* 162:14 - 27.

de Munck C, Lemonsu A, Masson V, Le Bras J, Bonhomme M (2018) Evaluating the impacts of greening scenarios on thermal comfort and energy and water consumptions for adapting Paris city to climate change. *Urban Climate* 23:260 - 286.

Ng E, Ren C (2018) China's adaptation to climate & urban climatic changes: A critical review. *Urban Climate* 23:352 - 372.

O'Driscoll R, Stettler ME, Molden N, Oxley T, ApSimon HM (2018) Real world CO2 and NOx emissions from 149 Euro 5 and 6 diesel, gasoline and hybrid passenger cars. *Science of The Total Environment* 621:282-290.

Oliphant AJ, Stein S, Bradford G (2018) Micrometeorology of an ephemeral desert city, the Burning Man experiment. *Urban Climate* 23:53 - 70.

Perera NGR, Emmanuel R (2018) A Local Climate Zone based approach to urban planning in Colombo, Sri Lanka. *Urban Climate* 23:188 - 203.

Perini K, Chokhachian A, Dong S, Auer T (2017) Modeling and simulating urban outdoor comfort: Coupling ENVI-Met and TRNSYS by grasshopper. *Energy and Buildings* 152:373 - 384.

Petit-Boix A, Devkota J, Phillips R, Vargas-Parra MV, Josa A, Gabarrell X, Rieradevall J, Apul D (2018) Life cycle and hydrologic modeling of rainwater harvesting in urban neighborhoods: Implications of urban form and water demand patterns in the US and Spain. *Science of The Total Environment* 621:434-443.

Pili S, Desogus G, Melis D (2018) A GIS tool for the calculation of solar irradiation on buildings at the urban scale, based on Italian standards. *Energy and Buildings* 158:629 - 646.

Pratt TL, Horton JW, Munoz J, Hough SE, Chapman MC, Olgun CG (2017) Amplification of Earthquake Ground Motions in Washington, DC, and Implications for Hazard Assessments in Central and Eastern North America. *Geophysical Research Letters* 44:12150–12160.

Richter A, Ruck B, Mohr S, Kunz M (2018) Interaction of severe convective gusts with a street canyon. *Urban Climate* 23:71 - 90.

Rizwan Yousaf M, Sami Yilbas B, Ali H (2018) Assessment of optical transmittance of oil impregnated and non-wetted surfaces in outdoor environment towards solar energy harvesting. *Solar Energy* 163:25 - 31.

Rojas JLF, Pereira AJ, Karam HA, Vemado F, Masson V (2018) Effects of Explicit Urban-Canopy Representation on Local Circulations Above a Tropical Mega-City. *Boundary-Layer Meteorology* 166:83–111.

Ronda RJ, Steeneveld GJ, Heusinkveld BG, Attema JJ, Holtslag AAM (2017) Urban Finescale Forecasting Reveals Weather Conditions with Unprecedented Detail. *Bulletin of the American Meteorological Society* 98:2675-2688.

Rosso F, Pisello AL, Castaldo VL, Fabiani C, Cotana F, Ferrero M, Jin W (2017) New cool concrete for building envelopes and urban paving: Optics-energy and thermal assessment in dynamic conditions. *Energy and Buildings* 151:381 - 392.

Ruiz MA, Sosa MB, Correa EN, Cantón MA (2017) Design tool to improve daytime thermal comfort and nighttime cooling of urban canyons. *Landscape and Urban Planning* 167:249 - 256.

Rumsey CA, Miller MP, Schwarz GE, Hirsch RM, Susong DD (2017) The role of baseflow in dissolved solids delivery to streams in the Upper Colorado River Basin. *Hydrological Processes* 31:4705-4718.

Scharf B, Zluwa I (2017) Case study investigation of the building physical properties of seven different green roof systems. *Energy and Buildings* 151:564 - 573.

Schilling KE, Streeter MT, Bettis EA, Wilson CG, Papanicolaou AN (2018) Groundwater monitoring at the watershed scale: An evaluation of recharge and nonpoint source pollutant loading in the Clear Creek Watershed, Iowa. *Hydrological Processes* 32:562-575.

Schinasi LH, Benmarhnia T.and De Roos AJ (2018) Modification of the association between high ambient temperature and health by urban microclimate indicators: A systematic review and meta-analysis. *Environmental Research* 161:168-180.

Schram-Bijkerk D, Otte P, Dirven L, Breure AM (2018) Indicators to support healthy urban gardening in urban management. *Science of The Total Environment* 621:863-871.

Seino N, Aoyagi T, Tsuguti H (2018) Numerical simulation of urban impact on precipitation in Tokyo: How does urban temperature rise affect precipitation?. *Urban Climate* 23:8 - 35.

Shen R, Schafer K, Shao L, Schnelle-Kreis J, Wang Y, Li F, Liu Z, Emeis S, Schmid HP (2017) Chemical characteristics of PM2.5 during haze episodes in spring 2013 in Beijing. *Urban Climate* 22:51 - 63.

Sherbakov T, Malig B.and Guirguis K, Gershunov A, Basu R (2018) Ambient temperature and added heat wave effects on hospitalizations in California from 1999 to 2009. Environmental Research 160:83-90.

Shih W-M, Lin T-P, Tan N-X, Liu M-H (2017) Long-term perceptions of outdoor thermal environments in an elementary school in a hot-humid climate. *International Journal of Biometeorology* 61:1657–1666.

Shirzadi M, Mirzaei PA, Naghashzadegan M (2017) Improvement of k-epsilon turbulence model for CFD simulation of atmospheric boundary layer around a high-rise building using stochastic optimization and Monte Carlo Sampling technique. *Journal of Wind Engineering and Industrial Aerodynamics* 171:366–379.

da Silveira Hirashima SQ, Katzschner A, Ferreira DG, de Assis ES, Katzschner L (2018) Thermal comfort comparison and evaluation in different climates. *Urban Climate* 23:219 - 230.

Simpson MJ, Hirsch A, Grempler K, Lupo A (2017) The importance of choosing precipitation datasets. *Hydrological Processes* 31:4600-4612.

Skelhorn CP, Lindley S, Levermore G (2018) Urban greening and the UHI: Seasonal trade-offs in heating and cooling energy consumption in Manchester, UK. *Urban Climate* 23:173 - 187.

Stewart RD, Lee JG, Shuster WD, Darner RA (2017) Modelling hydrological response to a fully-monitored urban bioretention cell. *Hydrological Processes* 31:4626-4638.

Su H, Tian S, Cai Y, Sheng Y, Chen C, Najafian M (2017) Optimized extreme learning machine for urban land cover classification using hyperspectral imagery. *Frontiers of Earth Science* 11:765-773.

Tarawally M, Xu W, Hou W, Mushore TD (2018) Comparative Analysis of Responses of Land Surface Temperature to Long-Term Land Use/Cover Changes between a Coastal and Inland City: A Case of Freetown and Bo Town in Sierra Leone. *Remote Sensing* 10:

Thorsson S, Rayner D, Lindberg F, Monteiro A, Katzschner

L, Lau KK-L, Campe S, Katzschner A, Konarska J, Onomura S, Velho S, Holmer B (2017) Present and projected future mean radiant temperature for three European cities. *International Journal of Biometeorology* 61:1531–1543.

Tian Y, Bai X, Qi B, Sun L (2017) Study on heat fluxes of green roofs based on an improved heat and mass transfer model. *Energy and Buildings* 152:175 - 184.

Tsitoura M, Michailidou M, Tsoutsos T (2017) A bioclimatic outdoor design tool in urban open space design. *Energy and Buildings* 153:368 - 381.

Tsoka S, Tsikaloudaki K, Theodosiou T (2017) Urban space's morphology and microclimatic analysis: A study for a typical urban district in the Mediterranean city of Thessaloniki, Greece. *Energy and Buildings* 156:96 - 108.

Turrini E, Carnevale C, Finzi G, Volta M (2018) A non-linear optimization programming model for air quality planning including co-benefits for GHG emissions. *Science of The Total Environment* 621:980-989.

Vanderhaegen S, Canters F (2017) Mapping urban form and function at city block level using spatial metrics. *Landscape and Urban Planning* 167:399 - 409.

Vermeulen T, Merino L, Knopf-Lenoir C, Villon P, Beckers B (2018) Periodic urban models for optimization of passive solar irradiation. *Solar Energy* 162:67 - 77.

Vieira J, Matos P, Mexia T, Silva P, Lopes N, Freitas C, Correia O, Santos-Reis M, Branquinho C, Pinho P (2018) Green spaces are not all the same for the provision of air purification and climate regulation services: The case of urban parks. *Environmental Research* 160:306-313.

Viippola V, Whitlow TH, Zhao W, Yli-Pelkonen V, Mikola J, Pouyat R, SetÃ¤lÃ¤ H (2018) The effects of trees on air pollutant levels in peri-urban near-road environments. *Urban Forestry & Urban Greening* 30:62-71.

Wagner P, Schafer K (2017) Influence of mixing layer height on air pollutant concentrations in an urban street canyon. *Urban Climate* 22:64 - 79.

Walikewitz N, Jänicke B, Langner M, Endlicher W (2018) Assessment of indoor heat stress variability in summer and during heat warnings: a case study using the UTCI in Berlin, Germany. *International Journal of Biometeorology* 62:29–42.

Wang H, Xiang Z, Wang L, Jing S, Lou S, Tao S, Liu J, Yu M, Li L, Lin L, Chen Y, Wiedensohler A, Chen C (2018) Emissions of volatile organic compounds (VOCs) from cooking and their speciation: A case study for Shanghai with implications for China. *Science of The Total Environment* 621:1300-1309.

Wang W, Ng E (2018) Air ventilation assessment under unstable atmospheric stratification: A comparative study for Hong Kong. *Building and Environment* 130:1 - 13.

Wang X, Li Y, Wang K, Yang X, Chan PW (2017) A Simple Daily Cycle Temperature Boundary Condition for Ground Surfaces in CFD Predictions of Urban Wind Flows. *Journal of Applied Meteorology and Climatology* 56:2963-2980.

Ward HC, Tan YS, Gabey AM, Kotthaus S, Grimmond CSB (2018) Impact of temporal resolution of precipitation forcing data on modelled urban-atmosphere exchanges and surface conditions. *International Journal of Climatology* 38:649–662.

Watanabe S, Ishii J (2017) Mitigation of pedestrian heat stress using parasols in a humid subtropical region. *International Journal of Biometeorology* 61:2009–2019.

Weiss DJ, Nelson A, Gibson HS, Temperley W, Peedell S, Lieber A, Hancher M, Poyart E, Belchior S, Fullman N, Mappin B, Dalrymple U, Rozier J, Lucas TCD, Howes RE, Tusting LS, Kang SY, Cameron E, Bisanzio D, Battle KE, Bhatt S, Gething PW (2018) A global map of travel time to cities to assess inequalities in accessibility in 2015. *Nature* 553:333+.

Wetherley EB, Roberts DA, McFadden JP (2017) Mapping spectrally similar urban materials at sub-pixel scales. *Remote Sensing of Environment* 195:170 - 183.

Wilson DC (2018) Potential urban runoff impacts and contaminant distributions in shoreline and reservoir environments of Lake Havasu, southwestern United States. *Science of The Total Environment* 621:95-107.

Wong HT, Wang J, Yin Q, Chen S, Lai PC (2017) The potential benefits of location-specific biometeorological indexes. *International Journal of Biometeorology* 61:1695–1698.

Worrall F, Burt TP, Howden NJ, Hancock GR, Wainwright J (2018) The fate of suspended sediment and particulate organic carbon in transit through the channels of a river catchment. *Hydrological Processes* 32:146-159.

Wu Z, Chen L (2017) Optimizing the spatial arrangement of trees in residential neighborhoods for better cooling effects: Integrating modeling with in-situ measurements. *Landscape and Urban Planning* 167:463 - 472.

Xiao Y, Wang L, Yu M, Shui T, Liu L, Liu J (2018) Characteristics of indoor/outdoor PM2.5 and related carbonaceous species in a typical severely cold city in China during heating season. *Building and Environment* 129:54 - 64.

Xiao Y, Zhang T, Wang L, Liang D, Xu X (2017) Analytical and experimental study on dissolved pollutant washoff over impervious surfaces. *Hydrological Processes* 31:4520-4529.

Xu H, Hu X, Guan H, He G (2017) Development of a fine-scale discomfort index map and its application in measuring living environments using remotely-sensed thermal infrared imagery. *Energy and Buildings* 150:598 - 607.

Xu Y, Ren C, Ma P, Ho J, Wang W, Lau KK-L, Lin H, Ng E (2017) Urban morphology detection and computation for urban climate research. *Landscape and Urban Planning* 167:212 - 224.

Yamato H, Mikami T, Takahashi H (2017) Impact of sea breeze penetration over urban areas on midsummer temperature distributions in the Tokyo Metropolitan area. *International Journal of Climatology* 37:5154–5169.

Yang J, Wang Z-H (2017) Planning for a sustainable desert city: The potential water buffering capacity of urban green infrastructure. *Landscape and Urban Planning* 167:339 - 347.

Yuan C, Norford L, Ng E (2017) A semi-empirical model for the effect of trees on the urban wind environment. *Landscape and Urban Planning* 168:84 - 93.

Zeng C, Bai X, Sun L, Zhang Y, Yuan Y (2017) Optimal parameters of green roofs in representative cities of four climate zones in China: A simulation study. *Energy and Buildings* 150:118-131.

Zhang L, Zhan Q, Lan Y (2018) Effects of the tree distribution and species on outdoor environment conditions in a hot summer and cold winter zone: A case study in Wuhan residential quarters. *Building and Environment* 130:27 - 39.

Zhao Q, Yang J, Wang Z-H, Wentz EA (2018) Assessing the Cooling Benefits of Tree Shade by an Outdoor Urban Physical Scale Model at Tempe, AZ. *Urban Science* 2:4.

Zhao Z-Q, He B-J, Li L-G, Wang H-B, Darko A (2017) Profile and concentric zonal analysis of relationships between land use/land cover and land surface temperature: Case study of Shenyang, China. *Energy and Buildings* 155:282 - 295.

Zhu X, Li D, Zhou W, Ni G, Cong Z, Sun T (2017) An idealized LES study of urban modification of moist convection. *Quarterly Journal of the Royal Meteorological Society* 143:3228–3243.

Zinzi M, Carnielo E (2017) Impact of urban temperatures on energy performance and thermal comfort in residential buildings. The case of Rome, Italy. *Energy and Buildings* 157:20 - 29.

Upcoming Conferences...

EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY
Vienna, Austria • April 8–13, 2018
https://www.egu2018.eu/

AMERICAN ASSOCIATION OF GEOGRAPHERS (AAG) ANNUAL MEETING
New Orleans, Louisiana USA • April 10-14, 2018
http://annualmeeting.aag.org/

RESILIENT CITIES 2018, THE 9TH GLOBAL FORUM ON URBAN RESILIENCE AND ADAPTATION
Bonn, Germany • April 26-28, 2018
https://resilientcities2018.iclei.org

SMART AND SUSTAINABLE CITIES(SSC-2018)
Moscow, Russia • May 23-26, 2018
http://ssc-conf.org/

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 SSSION 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

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^{o} LIMIT
Hong Kong, China • December 10-12, 2018
http://www.plea2018.org/

Environmental Research Letters: Focus Collection

Focus on Sustainable Cities: Urban Solutions Toward Desired Outcomes

Guest Editors:

Matei Georgescu Arizona State University

Mazdak Arabi Colorado State University

Winston Chow National University of Singapore

Elizabeth Mack Michigan State University

Karen Seto Yale University

Scope

Urban sustainability research is broad, involves investigators from traditionally disparate disciplines, and is conducted across multiple spatial and temporal scales. Changes in urban systems - both natural and anthropogenic - demand assessment of urban vulnerability (e.g., infrastructure, socioeconomic, ecological, and climatic) with emphasis on chronic concerns (e.g., aging infrastructure) as well as acute risks (e.g., flooding). These range from access to reliable, affordable and secure natural capital, to community resilience, to socioeconomic and governing structures and policy dimensions that accelerate the process of transforming solutions to actionable science. The identification of place-specific documentation of urban pressures through preferred outcomes, via development of conceptual, theoretical, and modelling advances built upon a systems framework, is a key motivation of this focus collection.

This issue focuses on discovery of urban solutions aimed at accelerating transition to economically, socially, and environmentally resilient cities through integration of desired outcomes as a research framework. These innovations will leverage our ability to use resources more efficiently, with less waste, with governance structures in place to distribute authority and information in an equitable and efficient manner. For example, the reduction of the well-known Urban Heat Island (UHI) effect is in and of itself not a desired outcome (despite the overabundance of research specially focused on approaches that reduce urban temperatures); however, UHI reduction methods also result in potential energy demand decreases (with implications for greenhouse gas emissions), improved health through biometeorological considerations, greater social, environmental and economic justice, which are all examples of desired outcomes towards development of sustainable cities.

We invite contributions from researchers that identify integrative pathways to desired outcomes (e.g., as influenced by infrastructure development and resource utility) thereby characterizing the place-based pressures-outcomes relationship that fosters synergistic and innovative urban solutions. Papers that address desired outcomes through the following lenses are encouraged:

Integrated assessment, planning, and management of natural capital (land, water, and air) in urban areas

Urban water sustainability

Risk(s) from floods and climate extremes to assets and communities in a changing world (i.e., changes in economy, population, land use, and climate)

Food-Energy-Water nexus in cities

Urban infrastructure effects on community health & livability

Pieces focused on Asian/African cities are particularly welcome, although the geographical scope is global. We encourage you to contact the Guest Editors (e.g., with a working title/idea/abstract) to assess the appropriateness of your manuscript for this collection.

Most focus collection articles are invited, but unsolicited contributions are also encouraged. If you believe you have a suitable research letter article in preparation please send your pre-submission query either to the journal publishing team at erl@iop.org or via the Guest Editors listed above. All full articles should then be submitted using our online submission form.

Submission process

Articles submitted to focus collections must be of the same format and meet the same publication criteria as regular research letter articles in ERL. They are also subject to the same rigorous review process, high editorial standards and quality/novelty requirements. Please read the scope and key information page for more information before submitting. For more comprehensive information on preparing your article for submission and the options for submitting your article, please see our author guidelines.

All articles should be submitted using our online submission form. In the first step of the online form, under 'Manuscript Type' please select '**Focus on Sustainable Cities: Urban Solutions Toward Desired Outcomes**' in the 'Select Special Issue' drop down box. In the 'File Upload' step, please include a separate justification statement outlining how your article satisfies the publication criteria for this journal (see the 'submission requirements' section on the scope and key information page).

Deadline for submissions

Submissions will be accepted until **28 February 2019** however submissions earlier than this date are encouraged. ERL will publish this focus collection incrementally, adding new articles to this webpage as and when they are accepted for publication following peer review. Therefore, if you submit early in the period your article will not be held up waiting for other articles. For more info see: http://iopscience.iop.org/journal/1748-9326/page/Sustainable-Cities

ICUC10 in New York City - Register Now!

The **ICUC10** (http://www.icuc10.org/) will be in New York City this year from August 6 – 10! It is less than 136 days away, and preparations are in full swing. This promises to be another impactful conference with nearly 775 scientific papers including 433 Oral presentations. The ICUC10 team has also confirmed five outstanding plenary speakers, who will speak in the morning plenary session of each day. Following the plenary session each day will be five parallel slots for Oral presentation. The schedule will include nearly 100 talks on day 1 and day 3, and about 80 each on other days. There will also be two days with Poster presentations. A few invited sessions, special theme topical sessions, and panels are being finalized on topics that should be of broad interest to the participants. A banquet will be hosted on the evening of August 8 and the details will be posted on the conference website. At this point, knowing the travel season in New York City and the limited space that will be available for many venues, the organizers are requesting everyone to register for this conference as soon as possible!

Also, the organizers have received a large number of travel support requests and they are reviewing them in accordance with the criteria set by sponsors and the WMO. The plan is to notify the awardees by end of March to Mid- April. Again, due to the limited space for hotel and accommodations; it is critical that attendees register as soon as possible to secure a room. All information regarding international travel, hotel, accommodations, and local transport can be found on the conference website http://www.icuc10.org/ and https://www.ametsoc.org/ams/index.cfm/meetings-events/ams-meetings/10th-international-conference-on-urban-climate-14th-symposium-on-the-urban-environment/.

Some helpful links:

Conference webpage:

https://www.ametsoc.org/ams/index.cfm/meetings-events/ams-meetings/10th-international-conference-on-urban-climate-14th-symposium-on-the-urban-environment/

Location information:

https://www.ametsoc.org/ams/index.cfm/meetings-events/ams-meetings/10th-international-conference-on-urban-climate-14th-symposium-on-the-urban-environment/location/

Accommodations information:

https://www.ametsoc.org/ams/index.cfm/meetings-events/ams-meetings/10th-international-conference-on-urban-climate-14th-symposium-on-the-urban-environment/accommodations/

Visa information:

https://www.ametsoc.org/ams/index.cfm/meetings-events/ams-meetings/10th-international-conference-on-urban-climate-14th-symposium-on-the-urban-environment/visa-information-for-international-attendees/

WMO OMM

AMERICAN METEOROLOGICAL SOCIETY 1919

IAUC

INTERNATIONAL ASSOCIATION FOR URBAN CLIMATE

CUNY CREST SCIENCE & TECHNOLOGY TO SUSTAIN THE EARTH

The City College of New York

Call for proposals for next ICUC meeting (ICUC-11)

The International Association for Urban Climate (IAUC) (http://www.urban-climate.org) organizes an international conference on urban climatology at regular intervals. This year the International Conference on Urban Climate, ICUC-10 will be held jointly with the 14th AMS Symposium on the Urban Environment in New York City, USA from 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/

ICUC-10 is the continuation of a series of similar conferences starting in Kyoto, Japan in 1989, followed by those in Dhaka, Bangladesh in 1993, Essen, Germany in 1996, Sydney, Australia in 1999, Lodz, Poland in 2003, Göteborg, Sweden in 2006, Yokohama, Japan in 2009, Dublin, Ireland in 2012 and Toulouse, France in 2015. The success of this series helped to create a cohesive international community of urban climatologists. The aims of these conferences are to provide an international forum where the world's urban climatologists can meet to showcase and discuss modern developments in research, and the application of climatic knowledge to the design and management of cities. They cater to the interests of a diverse community of meteorologists, climatologists, hydrologists, ecologists, engineers, architects, urban planners and others interested in these topics.

We would like to start the process to identify the location and host of the next ICUC meeting which will probably be held in 2021. While the IAUC welcomes expressions of interest from all parties, we strive to maintain a geographical and climatological balance among host cities for this series. As such, the IAUC encourages applicants from regions that have been underrepresented among the list of recent host cities (e.g., tropical and subtropical Asian cities).

As a first step we invite 'expressions of interest' from those interested in hosting the next ICUC. The expression of interest should be brief (~1 page) and should indicate the proposed location (city, country), organizer's name, institutional affiliation(s) and the likely time frame for the conference. This information can be submitted as an email to the Secretary of the IAUC, David Sailor (dsailor@asu.edu) by **April 15, 2018**.

We will share all the expressions of interest received with all those who make a submission and with the IAUC Board. The purpose of sharing the expressions of interest is to streamline the process and to allow collaborations/discussion around the bids from those interested in hosting ICUC-11. We will subsequently (within about 2-3 weeks) then ask submitters to confirm their intent to submit a full proposal.

For those who wish to submit a **full proposal (due 15 June)**, we ask that the proposal be less than 8 pages long (single spaced, 11pt font) and include the following sections:

1. **Location for conference**. This section should discuss the location and facilities available. Indicate why the proposed location is a good choice for an ICUC conference. Please also indicate hotels, distance between hotels and conference venue, summary details of available meeting rooms, and availability of inexpensive housing options (e.g., for students). In this section please also discuss opportunities for social activities, tours, and local attractions that might be of interest to conference participants and their guests.
2. **Proposed timing of conference**. This should be a short section discussing the likely time frame for the conference, including one or more alternatives. A brief discussion of the benefits of the proposed timing is desired.
3. **Proposed registration or other fees**. Provide an initial estimate of the proposed fees for the conference (in USD) based on current prices. Also discuss how surpluses or deficits are to be handled. Budgets should assume 500 – 600 participants (with about 1/3 of the attendees being students); please indicate what the registration fee would cover. The IAUC intends for ICUC to break even; this may require organizers to budget for a small surplus. Conference organizers are responsible for any losses.
4. **Preprints and proceedings**. Discuss whether there will be a preprint volume or conference proceedings and the mode of dissemination (e.g. electronic and/or printed).
5. **Institutional / private / government support**. Indicate whether there is institutional support for holding the conference at this location. This might include suggestions for a joint conference with another society or organization and access to suitable persons/organization to form a local organizing committee.
6. **Familiarity with IAUC and ICUC**. Please indicate whether the organizers have attended previous ICUC and/or are familiar with the objectives of IAUC.

Organizers of the last 3 ICUC conferences are listed below for reference:

• G. Mills, Ireland (gerald.mills@ucd.ie) (ICUC-8)

• A. Lemonsu and V. Masson, France (aude.lemonsu@meteo.fr, valery.masson@meteo.fr) (ICUC-9)

• J. Gonzalez and D. Niyogi, USA (jgonzalezcruz@ccny.cuny.edu, dniyogi@purdue.edu)

These individuals can provide insight into the necessary financial and institutional support that is needed to run a successful conference. It must be appreciated that IAUC, as a 'dues-free' organization, has limited financial means; its main resource is the goodwill and enthusiasm of its members and the knowledge that designated ICUC meetings attract the best of the international urban climate community, and that our past success has created mutually beneficial inter-organizational linkages.

Full proposals should be submitted in electronic format to David Sailor (dsailor@asu.edu) by 15 June 2018. We will have initial evaluations with the Board of the IAUC and then ask finalists to prepare a presentation for the Board Meeting at ICUC-10. If you have any queries or would like to see what a full previous proposal looked like please contact David Sailor.

Applicants for ICUC-11 should be prepared to present their proposal to the IAUC Board on the afternoon of Sunday Aug 5th (the day before the start of ICUC-10).

Call for Luke Howard Award nominations

Dear Members,

I am pleased to announce the call for nominations to the '**Luke Howard Award for Outstanding Contributions to the Field of Urban Climatology**.' The Luke Howard Award may be given annually to an individual who has made outstanding contributions to the field of urban climatology in a combination of research, teaching, and/or service to the international community of urban climatologists.

IAUC members are requested to nominate suitable candidates for the Luke Howard Award. The person making the nomination will act as the coordinator to put together a nomination package (including a CV of the nominee and three letters of recommendation). Self-nominations are not permitted and current Awards Committee members cannot be evaluated. Submit complete nomination packets (single electronic submission) to the Awards Committee Chair, Dr. Nigel Tapper: nigel.tapper@monash.edu

Luke Howard Award Nomination Process:

1. Inform the Chair of the IAUC Awards Committee of the intent to nominate an individual. The intent to nominate should be communicated via email to the Awards Committee Chair by **20 April, 2018**.
2. Nomination materials should be collected by a nomination coordinator (i.e. the person notifying the Chair of the IAUC Awards Committee that a particular person will be nominated);
3. The coordinator should collect the following documentation:
   a) a five page candidate CV
   b) three letters of recommendation from IAUC members from at least two different countries, two pages in length.
4. Complete packages should reach the Chair by **25 May, 2018**.

Nominations will be active for three years, and updated information may be submitted for consideration in the second and third years.

The IAUC Awards committee will recommend the name of a recipient for consideration and approval by the IAUC Board.

The list of previous winners can be seen at: http://www.urban-climate.org/awards/the-luke-howard-award/

Nominations should reach the Awards Committee Chair (Dr. Nigel Tapper, email above) by **25 May, 2018**.

Thank you,

Nigel Tapper, IAUC Awards Committe Chair

IAUC Board Members & Terms

- Gerald Mills (UCD, Dublin, Ireland): 2007-2011; President, 2009-2013; Past President, 2014-2018 (nv)
- James Voogt (University of Western Ontario, Canada), 2000-2006; Webmaster 2007-2013; President, 2014-2018
- Rohinton Emmanuel (Glasgow Caledonian University, UK): 2006-2010; Secretary, 2009-2013; Past Secretary 2014-2018 (nv)
- David Pearlmutter (Ben-Gurion University of the Negev, Israel): Newsletter Editor, 2009-*
- Aude Lemonsu (CNRS, France): 2010-2014; ICUC-9 Local Organizer, 2013-2018 (nv)
- David Sailor (Arizona State University, USA): 2011-2015; Secretary, 2014-2018
- Alexander Baklanov (University of Copenhagen): 2013-2017
- Valéry Masson (Météo France, France): ICUC-9 Local Organizer, 2013-2018 (nv)
- Fei Chen (NCAR, USA): 2014-2018
- Edward Ng (Chinese University of Hong Kong, Hong Kong): 2014-2018
- Nigel Tapper (Monash University, Australia): 2014-2018
- Aya Hagishima (Kyushu University, Japan): 2015-2019
- Jorge Gonzales (CUNY, USA): ICUC-10 Local Organizer, 2016-2021
- Dev Niyogi (Purdue University, USA): ICUC-10 Local Organizer, 2016-2021
- R. Leena Jarvi (University of Helsinki, Finland): 2016-2020
- Ariane Middel (Arizona State University, USA): 2016-2020

** appointed members*
nv = non-voting

IAUC Committee Chairs

Editor, IAUC Newsletter: David Pearlmutter
Bibliography Committee: Matthias Demuzere
Chair Teaching Resources: Gerald Mills
Chair Awards Committee: Nigel Tapper
Webmaster: James Voogt

Urban Climate News – The Quarterly Newsletter of the International Association for Urban Climate

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The next edition of ***Urban Climate News*** will appear in late June. Contributions for the upcoming issue are welcome, and should be submitted by May 31, 2018 to the relevant editor.

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.

Bibliography: Matthias Demuzere and BibCom members
matthias.demuzere@ugent.be