Urban Climate News

Quarterly Newsletter of the IAUC

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From the IAUC President

Colleagues, welcome to the Summer 2017 edition of the *Urban Climate News*.

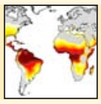
Let me first draw your attention to the initial call for papers for **ICUC-10** – joint with the AMS 14th Symposium on the Urban Environment and co-sponsored by the WMO. ICUC-10 is scheduled for **August 6-10, 2018 in New York City**, located on the campus of the City College of New York. The conference theme is Sustainable and Resilient Urban Environments. The experience of Superstorm Sandy has heightened awareness of New Yorkers to the threat of extreme weather and climate change and the need for urban scale adaptation and responses to both local and large scale climate change. The full call for papers provides a list of proposed themes, but members are also encouraged to contact the organizers – Jorge E. Gonzalez, Prathap Ramamurthy, and Dev Niyogi – via the conference email icuc10@ccny.cuny.edu with proposals for additional session themes.

As Northern Hemisphere summer begins, heat waves are in the news. Pakistan (April), many countries in Europe (June), and parts of the US southwest (June) have been experiencing temperatures that have been the hottest in decades. Such events are of increasing interest to urban residents, designers, planners, meteorologists and health officials given their important impacts on human comfort, health and energy use and the need to build resilient and more sustainable cities. Urban scale responses to such events are receiving increased attention from urban climate scientists; assessment of appropriate urban heat mitigation strategies is largely undertaken using numerical models. However, the literature shows a wide range of cooling magnitudes that arise from the similarly wide range of study scales, locations, assumptions, mitigation strategies tested, and cooling variables reported. In this issue, "Urban cooling from heat mitigation strategies: A systematic review of the numerical modeling literature" by Krayenhoff et al. (Arizona State University) seeks to develop an assessment of urban heat mitigation strategies. It proposes to assess studies in terms of their robustness and comparability and to recommend methodological approaches that can enhance these characteristics of future heat mitigation studies. This type of assessment is important for providing the best guidance to applied users on appropriate strategies and their efficacies.

Also on the theme of mitigation strategies, vegetation is an important tool of the urban designer for managing urban climates and provides urban heat mitigation benefits. Here Naomi Zurcher reports on the recent Urban Green Infrastructure Conference in Orvieto, Italy.

The numerical models used for urban heat mitigation – and many other applications - require significant data on the urban morphology. Acquisition and updating these data remain a challenge to providing the best input for urban-scale simulations. Verdonck et al. (Ghent University, Belgium) provide a feature overview on HUMINEX: The HUMan Influence Experiment to evaluate the quality of crowdsourced data on urban morphology.

Inside the Summer issue...



Within urban areas, local and large scale climate change combine to impact urban residents and activities. Emissions of greenhouse gas emissions from urban areas are a contributor to the large scale climate change. Urban scale modifications to urban fluxes of CO_2 from vegetation and urban soils are important to understanding the net impact of cities on atmospheric CO_2. Here, Decina et al. (Boston University) provide an urban project report on the contribution of soil respiration to atmospheric CO_2 in the greater Boston area.

The theme of resilience and sustainability is also reflected in the second in a series of 'special news pieces' by Paul Alexander that profiles Yokohama and Paris, two cities from the 11 that received the 2016 C40 Cities Award for addressing climate change. And finally, Michael Allen provides his take on the recent Joint Urban Remote Sensing Event, held in the rapidly developing - and hot – city of Dubai, UAE.

Thanks to all our contributors and to the UCN Team – Helen Ward, Joe McFadden, Matthias Demuzere, Paul Alexander and editor David Pearlmutter – for putting this issue together.

– James Voogt,
IAUC President

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Cities are tackling climate change: let's continue

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

Category:	**Adaptation Plans & Assessments**
Entrants (2016):	• Belo Horizonte (Brazil) • New York City (USA) • Paris, France
Winning City:	**Paris** *Paris Adaptation Strategy: Towards a More Resilient City* https://api-site.paris.fr/images/76271

It is well known within the urban climate community that Climate Change presents unique challenges for cities given the high concentration of people and vital critical infrastructure assets. The C40 award for Adaptation Plans and Assessments is awarded to cities that have acknowledged this challenge and developed a strategy to adapt their urban area to the inevitable consequences of Climate Change in order to protect people, the environment and assets. Much of the research within our own community speaks to this challenge: as global air temperature is employed as an indicator for Climate Change, the UHI is a strong indicator of locations across a city that deserve particular attention, enabling targeted intervention measures to be developed, implemented and monitored.

Paris was the winner of the C40 award for Adaptation Planning and Assessment. Paris is a city that has been the focus of much research from our own community, and has served as a negative example of what can go wrong when we do not account for the UHI effect, specifically, the 2003 European heatwave and its consequences has served as a justification for much research into the UHI in recent years. The Paris Adaptation Strategy demonstrates that city officials, researchers and the wider population not only recognise the importance of the urban microclimate, they have learned from the devastating impacts of the 2003 (and subsequent) heatwaves, and are now implementing an ambitious strategy to ensure future Parisians are able to cope with Climate Change.

The Paris Adaption Strategy is aimed at tackling the main climate change-related challenges facing the city, including: heatwaves, the urban heat island effect, flooding and droughts. The programme is also concerned with a number of other sustainability issues, from air pollution and health related risks, to the climate refugees' challenge and water scarcity. The Strategy contains 30 objectives and 35 actions. In relation the UHI, the strategy aims to implement effective crisis management (improving the heatwave emergency plan, spray water in the city, etc.) and bolster climate-sensitive urban planning (in particular with the ambitious greening program and "the cooling pathways" initiative) and instigate blue-green adaptation measures designed to reduce the UHI effect and help Parisians cope during heatwaves.

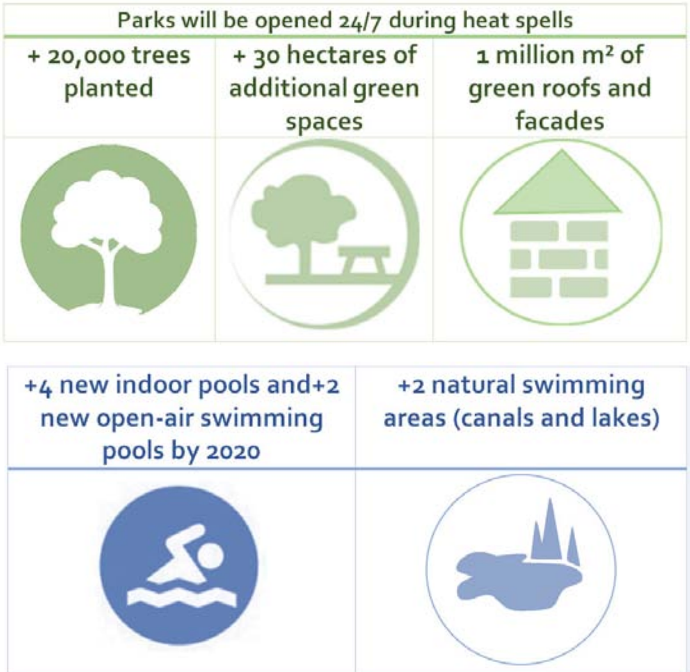


Figure 1. Overview of green (top) and blue (bottom) adaptation measures within the Paris Adaptation Strategy.

The plan is indeed strategic; the greening program and additional blue adaptation measures are geographically designed to ensure that the population are no more than a 7-minute walk from a cool place by 2020. The strategy also aims to establish a less vulnerable food supply. The strategy plans to establish 33 ha of urban agriculture spaces across Paris by 2020 and sets a target of 50% of municipal catering to come from sustainable food by 2020; 25% of food consumed in Paris should be locally produced by 2050. If realised, the Paris Adaptation Strategy may well result in the urban climate community referring to the city of Paris in the future not of what can go wrong, but rather as an example of how to deal with the UHI in a holistic way, exploiting economic, environmental and health co-benefits.

Fig. 2. Example of urban agriculture in the Paris Strategy.

Category: Clean Energy

Entrants (2016):
- Johannesburg (South Africa)
- Vancouver (Canada)
- Washington DC (USA)
- Yokohama (Japan)

Winning City: Yokohama
Yokohama Smart City Project (YSCP)
http://www.city.yokohama.lg.jp/ondan/english/yscp/

In recent years, the urban climate community has made significant advancements in the characterisation of cities, in particular, in developing a common nomenclature for buildings and neighbourhoods. Yet, a fundamental exercise we must all undertake involves a simple question: what are the boundaries of the city? Broadly, I would say there are two common definitions used within the urban climate community to answer this question: 1) the urban footprint (the collection of buildings, roads, pavements, vegetation, and people in geographic proximity), and/or 2) the urban system (as with the urban footprint, but additionally any energy or material consumption that takes place beyond the footprint in support of activities within the footprint).

If the urban climate community is to meaningfully communicate the benefits of our good work to town planners, energy managers and decision makers, we must be able to comfortably connect these two answers. This is especially true when it comes to energy demand, production, use and management, as often the actions taken within the urban footprint (such as greening, increasing the urban albedo) proposed by our community focus only on the demand aspect of the energy cycle.

Yokohama was the winning city for the C40 award in Clean Energy for the Yokohama Smart City Project (YSCP), which from an urban climate perspective, can be said to address almost every aspect of the energy cycle. The success of the YSCP lies in the simplicity of the approach – see Fig. 3 above.

By reducing the reliance on energy imported from outside the city from power plants, YSCP is developing an autonomous, decentralised and resilient energy production infrastructure for the city of Yokohama – see Fig. 4. Ultimately, what drives the YSCP approach is a question: how can citizens become effective managers of their energy use if they don't have a good handle on a) the resource available, and b) the cost of that resource? The answer: they cannot. This is why YSCP emphasises real-time smart building energy management systems (BEMS), home energy management systems (HEMS) and factory energy management systems (FEMS), all of which are coordinated by supervisory control and data analysis (SCADA). What makes the plan "smart" is that home owners and building managers will have real time monitoring systems installed in their homes along with photovoltaic (PV) panels. This allows citizens to exploit clean renewable energy, to see how much energy is available from their own PV system (and community energy systems including wind and PV power generator plants) and hence make better decisions as to their activities and associated energy use. As mentioned however, YSCP does not simply address the energy production and management side. The plan has a significant element of blue-green adaptation measures to reduce the demand side of the energy cycle by promoting passive cooling systems during the summer months and retro-fitting buildings to cope with colder winter months. This will increase the resilience of the city to climate change. Finally, YSCP addresses transport energy use by encouraging pedestrian access across the city in establishing pedestrian greenways, and working with the automotive industries located in Yokohama to increase the availability and uptake of electric vehicles. The YSCP fundamentally exploits the idea that urban citizens can have a significant impact on reducing GHG emissions, provided they are given the right tools.

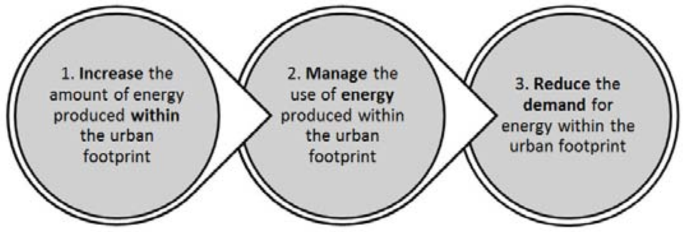


Figure 3. A synthesis of the approach of the award winning Yokohama Smart City Project.

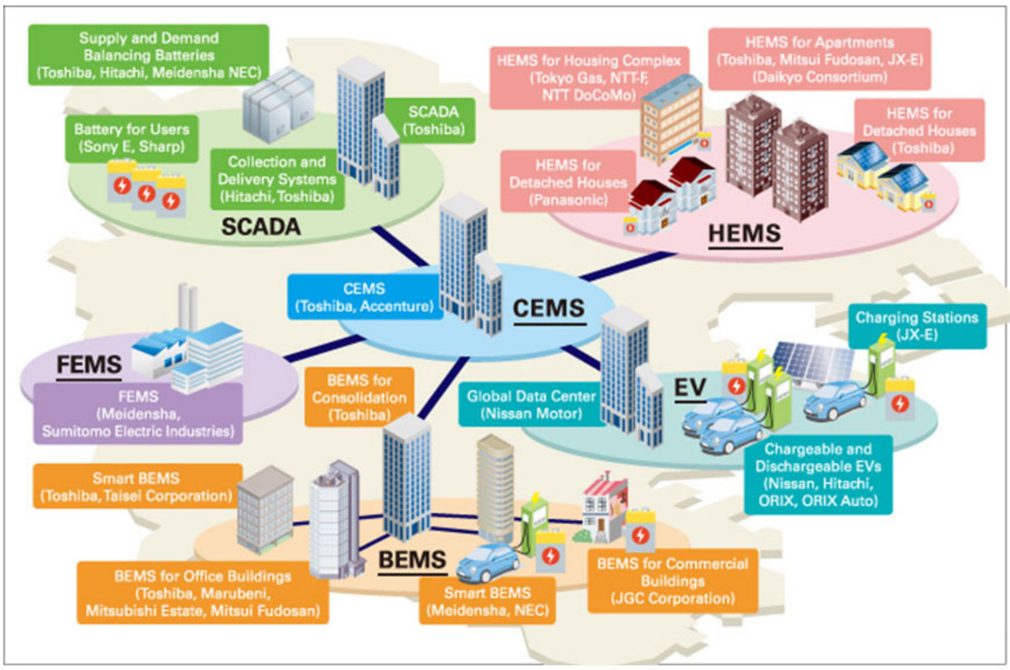


Fig. 4. The Smart City of Yokohama, emphasising harnessing and managing clean renewable energy from building scale, the neighbourhood scale right through to city scale.

AP-NORC poll: Few favor Trump move to ditch Paris accord

June 2017 — Less than one third of Americans support President Donald Trump's decision to withdraw from the Paris climate accord, a new poll shows, and just 18% of respondents agree with his claim that pulling out of the international agreement to reduce carbon emissions will help the U.S. economy.

The survey, conducted by the Associated Press-NORC Center for Public Affairs Research earlier this month, found that a majority of 52% worry that withdrawing will actually hurt the economy and 27% think it won't have an impact either way. But digging deeper into the numbers shows a sharp partisan divide on global warming, with Republicans more likely to align themselves with the president's views while 78% of Democrats think withdrawing from the Paris agreement will hurt the national economy. Among Republicans, just 24% think it will hurt, 40% think it will have no impact and 34% think it will help.

Donald Nolan is a New Jersey businessman who has spent years living and traveling overseas. He worries that Trump is undermining U.S. credibility abroad. An independent voter, Nolan said he strongly opposes pulling out of the Paris accord. "Where I live, we're 36 feet above sea level. If the polar ice caps melt, there won't be any dry land here," said Nolan, 60. "If you are pulling out of something that pretty much every other country in the world is a part of, then that is not seen as being a leader. When I lived overseas, America was always looked at as being first. But I see our position to be deteriorating."

Overall, 44% of Americans are very concerned and 26% are moderately concerned that withdrawing from the agreement will hurt the country's standing in the world, with that concern also dividing along party lines. By a 46 to 29% margin, more oppose than favor the U.S. withdrawing from the agreement. Democrats are far more likely to oppose than support withdrawing from the agreement, 69 to 16%. Republicans are more likely to support Trump's

Paris Mayor: Donald Trump has made a 'dramatic and unpopular' mistake in leaving Paris agreement

June 2017 — In November 2015, more than 190 nations came to Paris for 13 days of intense negotiations that resulted in the Paris Agreement on Climate Change. This historic international accord brought the nations of the world together in combatting the greatest threat our planet has ever faced.

Though not direct signatories to the agreement, mayors and cities played a pivotal role in offering tangible climate action and support for nations to put forward ambitious, but achievable, climate targets. In fact, while nation states were negotiating, we, along with Michael R. Bloomberg, the U.N. Special Envoy for Cities and Climate Change, convened a summit bringing together 1,000 mayors and cities at Paris City Hall. There we committed to tackle climate change through bold actions.

The incredible diplomatic achievement of the Paris agreement could not have happened without the decisive, ambitious role of the United States. And today, we witness U.S. President Donald Trump making a dramatic and unpopular mistake in electing to pull the U.S. out of the Paris Agreement.

As the chair of C40, a network of 91 of the world's major cities committed to tackling climate change and as the mayor of Paris, I urge the U.S. administration to reconsider this short-sighted decision. The years to 2020 will be crucial in determining if the worst effects of climate change can be avoided. American leadership on this urgent challenge is needed now more than ever.

Regardless of President Trump's decision, the great cities of the world, in particular the 12 American C40 cities, remain resolutely committed to doing what needs to be done to implement the Paris Agreement.

As mayors, we recognize that climate change poses a unique threat to the future of our planet. Already we see the effects of climate disruption every day, from hurricanes in New Orleans and New York to floods in Paris, Houston and Montreal to deadly heatwaves in Sydney to toxic air pollution in Beijing, New Delhi and other large cities.

We recognize the peril climate change poses to the health, prosperity, security and the very survival of our children and grandchildren.

Not a day goes by without C40 mayors on every continent making bold and pioneering choices, to help create a cleaner, safer world for the next generations. We will not relent. We already know that cities are where the future happens first, and we remain committed to a greener future for all. There is no alternative.

— Anne Hidalgo, Mayor of Paris and Chair of the C40 Cities Climate Leadership Group. *Source:* http://www.newsweek.com/anne-hidalgo-paris-agreement-climate-change-donald-trump-619309 withdrawal, 51 to 20%. Independents are mixed in their views: 25% support the withdrawal, 36% are opposed and 37% don't feel strongly one way or the other. Similarly, 43% say they're very or extremely concerned that the U.S. withdrawing from the agreement will hurt global efforts to fight climate change, while 25% are moderately concerned (72% percent of Democrats, but just 13% of Republicans, are very concerned.)

Sixty-four percent of Americans disapprove and just 34% approve of how Trump is handling the issue of climate change, the poll shows. That's similar to his overall approval rating, but there are other areas where Trump performs a bit better. For example, 43 percent approve of how he's handling the economy and 47 percent approve of how he's handling the threat of terrorism.

The poll shows about two-thirds of Americans think that climate change is happening, while only about 1 in 10 think it's not. The remaining quarter aren't sure one way or another. Seven in 10 Americans – including some of those who aren't sure whether climate change is actually happening – think it's a problem that the U.S. government should be working to address. Among those who do think it's a problem the government should address, more oppose than support withdrawing from the Paris agreement by a 60 to 21%margin. More than half of Americans –53% – say climate change is a very or extremely important issue to them. Women are more likely than men to call climate change an important issue, 59 to 47%.

Bonnie Sumner, an independent voter who has lived in Colorado the last nine years, is among those who said doing something to combat climate change is important. She said her community in the Rocky Mountains is still dealing with the after effects of a devastating wildfire. "It's definitely gotten hotter than it used to be," said Sumner, 72. "I try to keep up with science, not people who have money to be made by not wanting things to change."

The poll shows that 35% of Americans have a great deal of confidence in the scientific community, 51% have some confidence, and 11% have hardly any confidence. But, again, there's a big political divide: 53% of Democrats, but just 22% of Republicans and 19% of independents, say they have a great deal of confidence in scientists.

Sumner said Trump is too quick to dismiss the evidence of global warming compiled by climate scientists. "His position, as it is with too many other things, is, 'I know what's best, I know better than everybody else, and this is a hoax, and this is fake news,'" she said. "I'm frightened for us, my children and my grandchildren. We only have one earth, we have to work together."

The AP-NORC poll of 1,068 adults was conducted June 8-11 using a sample drawn from NORC's probability-based AmeriSpeak panel, which is designed to be representative of the U.S. population. The margin of sampling error for all respondents is plus or minus 4.1%. Respondents were first selected randomly using address-based sampling methods, and later interviewed online or by phone. *Source:* http://abcnews.go.com/Technology/wireStory/ap-poll-agree-trump-move-ditch-paris-accord-48148037

During heat waves, urban trees can increase ground-level ozone

Planting trees is a popular strategy to help make cities "greener," both literally and figuratively. But scientists have found a counterintuitive effect of urban vegetation: During heat waves, it can increase air pollution levels and the formation of ozone. Their study appears in ACS' journal *Environmental Science & Technology*.

Previous research has shown that planting trees in cities can have multiple benefits, including storing carbon, controlling storm water and cooling areas off by providing shade. This has spurred efforts in cities across the U.S. and Europe to encourage the practice. However, it's also known that trees and other plants release volatile organic compounds, or VOCs, that can interact with other substances and contribute to air pollution. And when it's hot, plants release higher levels of VOCs. Galina Churkina and colleagues wanted to investigate what effects heat waves and urban vegetation might have on air pollution.

The researchers compared computer models of air pollutant concentrations in the Berlin-Brandenburg metropolitan area in Germany in the summer of 2006, when there was a heat wave, and the summer of 2014, which had more typical seasonal temperatures. The simulation showed that

Trees in cities have many benefits but can increase ozone during heat waves. *Source:* sciencedaily.com

during the summer of 2006, VOCs from urban greenery contributed to about 6 to 20% of the ozone formation, and that during the heat wave period, the contribution spiked to up to 60%. The researchers suggest that in addition to tree-planting campaigns, efforts to improve cities' environments should include other measures such as reducing vehicular traffic, a major source of nitrogen oxides that can react with VOCs and form ozone. *Source:* https://www.sciencedaily.com/releases/2017/05/170517090555.htm

Three-quarters of the planet could face deadly heatwaves by 2100

And a third of us already do.

June 2017 — It killed 739 people in Chicago in 1995. In Europe in 2003, it claimed another 70,000 lives. Just seven years later, it would take down 55,000 more in Russia. Extreme heat can and does kill. And while those heatwaves garnered global attention, according to a study released today in the journal *Nature*, they're more common than we think. The study's authors note that worldwide, some 30% of people are exposed to life-threatening extreme heat for at least 20 days of each year. If we do nothing to reduce climate changing emissions that are helping to push the mercury higher, they write, 74% of people will experience routine extreme heat events by 2100. And as is already the case today, at least some of those people will die.

Unlike floods, earthquakes, and tornadoes, heat's devastation is insidious, pushing on the human body's limits until it suddenly exceeds them. Above a certain threshold – one that's maddeningly difficult to determine due to multiple variables like humidity, sunlight, breeziness, and weather – heat just makes it harder to exist. The hemoglobin that picks up oxygen and carries it in our blood has a harder time binding to it as temperatures rise, turning respiration into a chore – each breath gains us less oxygen. Meanwhile, sweat tends to desert us if we're very young, elderly, or if the air is already very humid. Sweat cools the body through evaporation, but young children and the elderly tend not to sweat as much, and when the air is already thick with humidity, sweat doesn't evaporate – so our bodies don't cool off.

All of this would be taxing enough in a pristine environment, but our anthropogenic altered world is anything but pristine. Hot weather mixes our airborne pollutants with sunlight, creating ground level ozone (smog's main ingredient). According to the United States Environmental Protection Agency EPA, poor air quality can cause chest pain, coughing, throat irritation, and congestion and worsen bronchitis, emphysema, and asthma. One study found that air pollution, including smog, kills more than three million people per year.

To estimate how many more people will be exposed to stifling temperatures under climate change, the study authors looked at 911 peer reviewed papers, which included data from 1,949 case studies on regions where extra deaths were linked to high temperatures.

But how to determine which temperatures were hot enough to be considered...hot?

"That is a big problem we encountered," says lead author Camil Mora, a biogeography researcher at the University of Hawaii at Manoa. "There are many definitions of a what a heatwave is, and this is what makes this paper so unique. What we decided to do once we collected all of the data was to let the threshold under which people died determine the climatic condition of what counts as a heatwave."

It's getting hot out there. ***Source:*** **popsci.com**

Mora discovered that in some instances, deaths increased at temperatures as low as 72 degrees Fahrenheit. "That's mind-blowing, people dying at such low temperatures, but we found out that there was super high humidity in those places," says Mora. "And you had the opposite case as well, where people died at super-hot temperatures but it was unusually dry."

Not everyone agrees that this is the best way to study heat. "It's a bit of an ambitious study, they're trying to answer a really important question," says Daniel Mitchell, an atmospheric scientist at Oxford University who was not a part of the study. "But I don't necessarily think they're going about it in the right way." Mitchell thinks that defining deadly heat based on a literature search instead of some underlying physical science is problematic.

"There are lots of things that can lead to mortality that have nothing to do with the climate. A good example was Egypt 2015, the heat wave there where a large number of people died, but they all died in places like prisons and psychiatric hospitals," Mitchell says. "And the reason was because the timing of the heat wave was such that they didn't have people around to take care of them."

Similarly, the 2003 European heatwave was so deadly in France because it coincided with the country's fairly ubiquitous habit of going on vacation in August. Many of the cities emptied out, leaving behind elderly people without caregivers. The sad timing was made worse by the region's general inability to deal with such heat—air conditioners were scarce, and things like cooling centers (which are common in America) are rare in Paris. French cities fared better in subsequent heat waves: hot summers have increasingly become their new normal, so they're better equipped to survive them.

Mitchell also notes that the study extrapolates what will happen based on data mostly in the north, despite the fact that many countries, especially those in the developing world, are quite different.

"Our cities are very different in the northern mid-latitudes than the tropical belt of Africa," says Mitchell. "Our economy is very different, with a lot of societal factors that would lead to very different casualties in Europe, and they assumed that it's the same across the board."

But while regions closer to the poles will have the most warming, Mora says, people in the tropics are actually the most vulnerable. Even though it won't warm as much, and even though they've already had to deal with potentially dangerous temperatures in ways many northern cities have not, they're closer to that threshold beyond which people start succumbing – it's already hot and humid there. So even relatively small amounts of warming could prove disastrous.

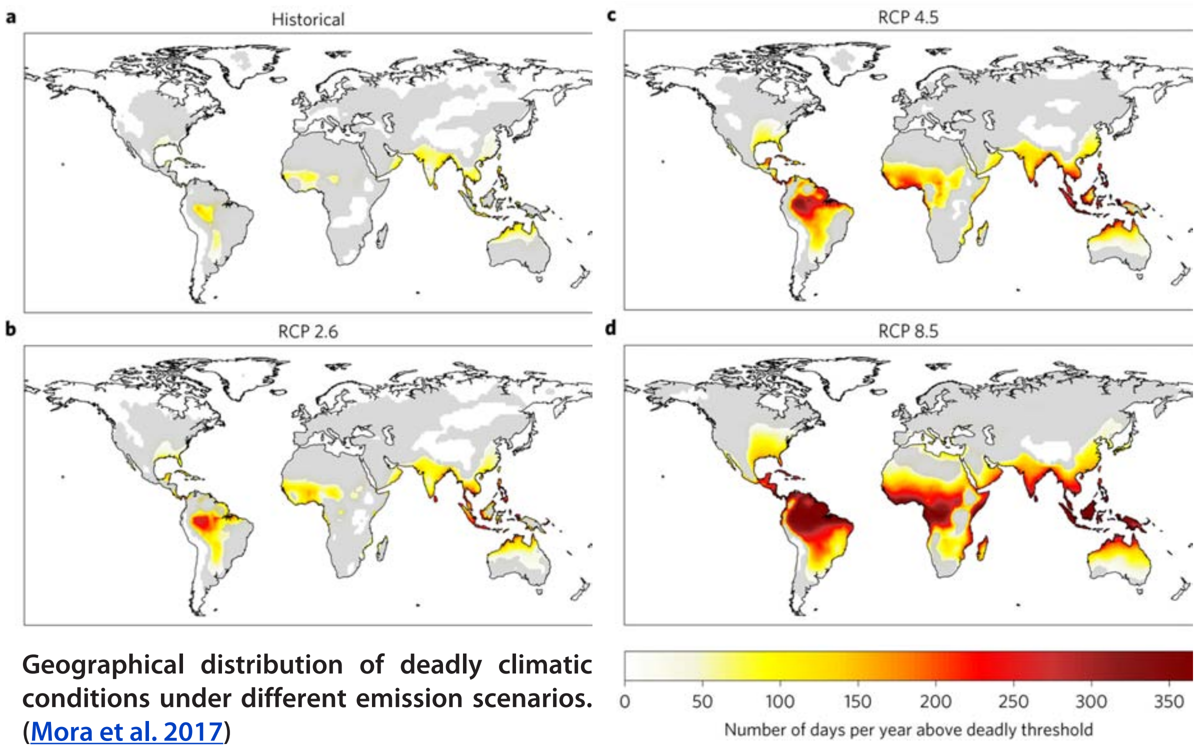
In other words, extrapolating what will happen in the tropics based on the northern mid-latitudes might be underestimating the impact, not overestimating it. And Mora has already found examples of people shifting their behaviors to cope with the intense heat.

A 2015 study published in *Nature Climate Change* found that in Australia, worker absenteeism and reductions during a 2013/2014 heatwave cost $6.2 billion U.S. dollars (roughly 0.3% of the country's GDP). A 2009 study published in the *International Journal of Public Health* looking at workers on construction sites in India and in shoe factories in Vietnam found that lengthy rest periods during the hottest days made 8-10 hour days stretch to 15-16 hours. Even if heatwaves don't kill us, they certainly take their toll.

Scorching hot temperatures may increase deaths in the future. ***Source:*** **popsci.com**

Despite the issues that Mitchell sees in the study, he thinks it's making a necessary point. "It's an important study and in some ways it's a good step in the right direction," says Mitchell. "It's highlighting that, for instance, in terms of climate-related variables, they are increasing. It's highlighting that in the past these things have often lead to high mortality counts. It is a paper that is advocating to start looking at adaptation for large heat waves."

"It's imprisoning people indoors," says Mora. "We're becoming prisoners of our houses to cope with these heat waves." *Source:* http://www.popsci.com/deadly-heat-wave-climate-change



Geographical distribution of deadly climatic conditions under different emission scenarios. (Mora et al. 2017)

'Cool pavement' to cut urban street heat gets first California tryout

May 2017 — The new street seal gushed from a downpipe Saturday onto Jordan Avenue, then spread like paint to turn a half block of black into a sea of gray.

The morning temperature of the black asphalt in the middle of a nearby intersection read 93 degrees. The new light gray surface on Jordan Avenue read a cool 70 – on what would turn out to be the first heat wave of the year.

"It's awesome. It's very cool – both literally and figuratively," exclaimed Councilman Bob Blumenfield, whose Los Angeles district includes Canoga Park, squinting into the laser handheld thermometer. "We are trying to control 'the heat island effect'" – or hotter temperatures caused by urban sprawl.

"The downside: we won't be able to fry eggs on the streets." Los Angeles, which had pioneered the use of compressed natural gas trash trucks and other vehicles, is now at the forefront of developing a "cool pavement" to lower temperatures along its thousands of miles of baking asphalt streets.

For the first time in the Golden State, it is testing a reflective street surface officials say could cut public road temperatures, cool the insides of nearby buildings, lessen air pollution and reduce the threat of deaths linked to increasingly hotter heat waves.

Before afternoon temperatures could push 100, city street workers spread a thin gray coating of CoolSeal into the heart of one of its hottest neighborhoods. "The city's going to get hotter because of climate change, particularly this neighborhood of the west San Fernando Valley," said Greg Spotts, assistant director of the Bureau of Street Services, who doubles as its acting chief sustainability officer. "The phenomenon called the heat island effect means the city is hotter than the surrounding countryside. "We're exploring ways to reduce the heat island effect by reducing the absorption of heat in the built environment."

Street Services, working in conjunction with GuardTop LLC, an asphalt coating manufacturer based in Dana Point, had first tested the cool pavement seal in the Sepulveda Basin. Asphalt at a parking lot at the Balboa Sports Complex once averaged 160 degrees in summer. After the seal was applied two years ago, company officials say, surface temperatures dropped to between 135 to 140 degrees.

Now, after rigorous testing for durability and wet skid potential, the CoolSeal coating was being slathered across a half block of Jordan Avenue just north of Hart Street near the headwaters of the Los Angeles River. If the new seal could boost solar reflectivity – and dramatically cool a street lined with two-story apartments in the hottest region of the San Fernando Valley – it could do it anywhere, city officials said.

The experiment will soon be duplicated in 14 other council districts before the end of June. If successful, city officials hope to encourage manufacturers to help develop cool pavement that could be incorporated into a multimillion-dollar drive to fix a backlog of L.A.'s failing streets.

Sealant poured out onto the asphalt is spread around with squeegees. This is the first such installation on a public street in the State of California. *Source:* mercurynews.com

"I'm thrilled to be here. This is a great day for all of us. We look forward to seeing what the results will be," said Kevin James, president of the Los Angeles Board of Public Works.

A CoolSeal coating could cost an estimated $40,000 per mile and last seven years, city officials said. But that's subject to change pending pavement innovation.

"We're going to try to make Los Angeles as cool as possible," said Jeff Luzar, national sales director for GuardTop, a privately owned firm that has coated mostly playgrounds and parking lots. "We're going to be the coolest island in Southern California."

Average temperatures in Los Angeles have risen 5 degrees in the past 100 years on account of the heat island effect produced by miles of asphalt freeways, roads, parking lots, roofs and more, climatologists say. In summer, temperatures have risen an average 10 degrees.

In addition, extreme heat days near 100 degrees have risen from two a year in 1906 to 24, while their duration has increased from a few days in a row to heat waves of two weeks, said climatologist Bill Patzert of the Jet Propulsion Laboratory. "I'm all for it," Patzert said of the cooler pavement. "We could certainly stop the rise – and perhaps reverse it."

Unfortunately, he added, the urban forest across Los Angeles is dying because of insufficient watering during the recent drought. "They can paint the streets gray," he said, "but when all these trees die, you'll see a dramatic increase in the heat island effect in the whole Basin."

The residents of Canoga Park were astonished, even thrilled, to see black asphalt turn a light shade of gray within 30 minutes. "I think it's awesome," said Partha Ghosh, 30, who lives at an apartment at Jordan Avenue and Hart Street, staring at the battleship-like surface. "Not too bright. Just perfect. I hope it could cool off my apartment." *Source:* http://www.mercurynews.com/2017/05/22/cool-pavement-to-cut-urban-street-heat-gets-first-california-tryout-in-canoga-park/

HUMINEX: The HUMan INfluence EXperiment to evaluate the quality of crowdsourced data on urban morphology

By Marie-Leen Verdonck[1] (marieleen.verdonck@ugent.be) Benjamin Bechtel[2], Matthias Demuzere[1], Daniel Fenner[3], Oscar Brousse[4] and Frieke Van Coillie[1]

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This article is a summary of: 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 and Verdonck ML (2017) Quality of Crowdsourced Data on Urban Morphology – The Human Influence Experiment (HUMINEX). *Urban Science* 1(2), 15.

Aim of HUMINEX

The HUMan Influence EXperiment (HUMINEX) was designed to evaluate how individual perception and bias impacts the mapping accuracy of cities following the World Urban Data Access and Portal Tools (WUDAPT) framework across different cities in the world. The overall aims of this first phase (HUMINEX 1.0) were to (1) investigate the quality of local climate zone (LCZ) maps produced by different individuals using the WUDAPT methodology; (2) address the influence of their individual perception and interpretation, which is based on their experience and prior knowledge; and (3) investigate how the mapping accuracy can be improved, e.g., by revision of the initial training data or by joining crowdsourced data from several operators. We refer you to the full paper by Bechtel et al. (2017) for more detailed information.

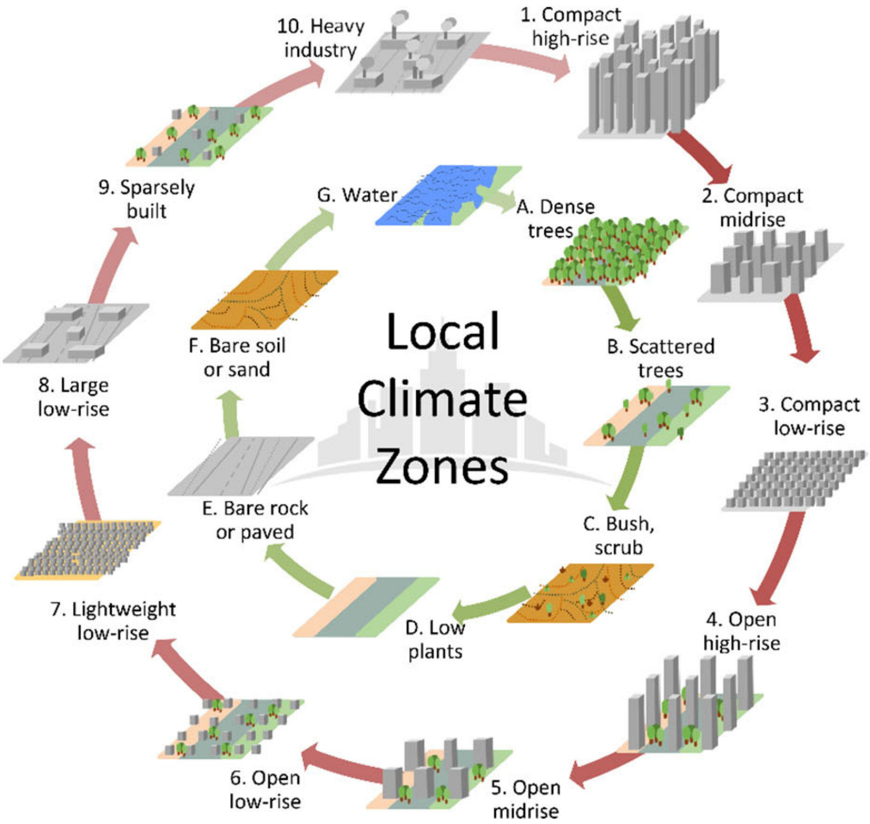
What is new in HUMINEX 2.0?

After the first phase of HUMINEX in 2015 and 2016, HUMINEX is currently being continued in a second phase. This includes a standardized introduction to the topic across participating institutions and a focus on a single city: Berlin, Germany. This could help to address further questions that remained unanswered after HUMINEX 1.0, such as: Can the quality of LCZ training areas (TAs) be assessed from the TA themselves? Can the quality of LCZ TAs be assessed from operator self-assessment? Does the personality of the operator influence the classification quality? Is local knowledge a key factor for an accurate LCZ classification? It goes without saying that education and the motivation of the operators are indispensable for achieving good results. Thus, improved course materials and a 'driving test' for LCZ knowledge to help become familiar with the LCZ scheme and to better recognize LCZ classes from aerial imagery are now incorporated in HUMINEX 2.0.

During HUMINEX 1.0 some courses had already started before the setup was finalized, and the metadata was thus not always collected during the mapping exercise. In these cases, the questionnaire was filled in retrospect, which impacted completeness and may have affected answers depending on the recall of the participants. For HUMINEX 2.0 we hence developed an online questionnaire including questions on personality, educational background, and city knowledge. The design of the questionnaire was influenced largely by results by Van Coillie et al. (2014), who found that the operator performance is mainly determined by demographic, non-cognitive and cognitive personality factors, and less by external and technical factors. After the exercise, a second self-assessment questionnaire is presented to each participant to evaluate the involvement of the operators in the experiment.

Who is experimenting and how can you join?

Currently, HUMINEX 2.0 is well on its way, but we are still searching for participants. Now already 82 students from four different universities (Ghent University, University of Leuven, Technische Universität Berlin, and University of Augsburg) are participating. Participation is however not limited to students or student courses; anyone can participate as an independent operator. For more information on the participation, we refer you to the WUDAPT website (http://www.wudapt.org/huminex-2-0/), where you can find all the information and course materials for HUMINEX 2.0. Please do not hesitate to contact us for more information or to inform us of your participation.



1	•Dense mix of tall B. Few/no trees. C: mostly paved. M: concrete, steel, stone, glass
2	•Dense mix of midrise B. Few/no trees. C: mostly paved. M: stone, brick, tile, concrete
3	•Dense mix of low-rise B. Few/no trees. C: mostly paved. M: stone, brick, tile, concrete
4	•Open arrangement of tall B. Abundance of low plants, scattered trees. M: concrete, steel, stone, glass
5	•Open arrangement of midrise B. Abundance of low plants, scattered trees. M: concrete, steel, stone, glass
6	•Open arrangement of low-rise B. Low plants, scattered trees. M: wood, brick, stone, tile, concrete
7	•Dense mix, 1-story B. C: mostly hard-packed. Lightweight M: wood, thatch, corrugated metal
8	•Open arrangement of large low-rise B. Few/no trees. C: mostly paved. M: steel, concrete, metal, stone
9	•Sparse arrangement of small or medium-sized B in a natural setting. Abundance low plants, scattered trees
10	•Low/midrise industrial structures. Few/no trees. C: mostly paved or hard-packed. M: metal, steel, concrete
A	•Heavily wooded landscape. C: mostly pervious (low plants). F: natural forest, tree cultivation, urban park
B	•Lightly wooded landscape. C: mostly pervious (low plants). F: natural forest, tree cultivation, urban park
C	•Open bushes, shrubs, short, woody trees. C: mostly bare soil/sand. F: natural scrubland or agriculture
D	•Landscape of grass, herbaceous plants/crops. Few/no trees. F: natural grassland, agriculture, urban park
E	•Landscape of rock or paved C. Few/no trees or plants. F: natural desert (rock) or urban transportation.
F	•Landscape of soil/sand C. Few/no trees or plants. F: natural desert or agriculture
G	•Large, open (seas, lakes), or small (rivers, reservoirs, lagoons) water bodies

Figure 1. Urban (1–10) and natural (A–G) LCZ types and their characteristics (adapted from Table 2 in (Stewart et al. 2012), text shortened, icons reworked) and colour code used in the WUDAPT framework. B: Buildings; C: cover; M: materials; F: function; Tall: >10 stories, Mid-rise: 3–9 stories, Low: 1–3 stories (Bechtel et al. 2017).

Why should we evaluate crowdsourced data in Local Climate Zone Mapping?

Cities play an important role in global environmental change, reflected in numerous publications on urban growth (Batty 2005; Schneider & Woodcock 2008), building urban resilience (Jha et al. 2013; Meerow et al. 2016), and smart cities and urban analytics (Batty 2013; White et al. 2016). However, consistent information on the place-specific character, related to form and function, of urban landscapes worldwide is needed to make informed decisions to understand the nature of urban risks, to provide a basis for planning sustainable cities, to transfer knowledge between cities, to run increasingly sophisticated models and to link the effects of global/regional environmental change to urban environments. Currently a dearth of information still exists on the internal make up of cities related to the above. To address this lacuna, Mills et al. (2015) recently launched the World Urban Database and Access Portal Tools (WUDAPT) project.

WUDAPT developed a method to classify urban areas into maps showing the basic physical geography of cities worldwide. The method uses a standard classification scheme (Local Climate Zones, Stewart & Oke 2012), Landsat data, and crowdsourced knowledge. The LCZ scheme (Figure 1) consists of ten urban and seven natural zones, all displaying a distinct thermal behaviour at the neighbourhood scale (≥1 km^2).

The scheme was designed to assess local climate impacts and to provide an objective framework for urban heat island research (Stewart et al. 2014; Alexander & Mills 2014; Arnds et al. 2017). But an LCZ map also describes the urban landscape in a general way (e.g., vegetative and building fractions), encoding its internal structure. A worldwide LCZ database on cities would provide much of the data infrastructure to support global initiatives on urban-scale risk assessment and appropriate adaptation and mitigation strategies. For WUDAPT, it was decided that a simple and efficient computing workflow based on free software and data was needed. This resulted in a universal methodology of a supervised classification (Bechtel et al. 2015) that uses free Landsat satellite imagery and high-resolution imagery from Google Earth as the basis for identifying and digitizing training areas (TAs), representing typical examples of the LCZs present in their city. This method has been implemented in a single LCZ classification tool in the open source SAGA software (Conrad et al. 2015) and has proven to be useful: to date, a large number of individuals around the world have classified over 50 cities worldwide (e.g. Bechtel et al. 2016; Danylo et al. 2016; Perera & Emmanuel 2016; Verdonck et al. 2017). The whole workflow is an iterative process during which the classification can be refined and improved; the classification workflow is shown in Figure 2. Detailed information on the use of the workflow is outlined on the WUDAPT website (www.wudapt.org).

The use of crowdsourced TAs makes WUDAPT an example of the crowdsourcing of geographic information – also referred to as volunteered geographic information (VGI) (Goodchild 2007) and citizen science – amongst other terms related to user-generated content (See et al. 2013). Generally, crowdsourcing involves the distribution of tasks to a crowd (Howe 2006). For WUDAPT, another important element in involving the crowd is to elicit the knowledge of individuals located in different cities around the world. Hence, members of the International Association for Urban Climate (IAUC) are the main contributors to WUDAPT due to their strong interest in urban climate related issues. However, anyone with an interest in contributing to the WUDAPT database can participate. Since the LCZ maps are intended for use in a range of different applications, such as climate models at various scales, there is a clear need for a common quality assessment process. Previous examinations of TAs for different cities revealed that not everyone in the crowd follows the WUDAPT recommendations for TA sizes and shapes, and that often LCZ TAs have simply been misidentified. This is mainly driven by the large variability in human interpretation of imagery, which is a common problem in supervised classification (Foody et al. 2013; Van Coillie et al. 2014). Similar concerns have recently been raised with respect to the quality of crowdsourced data (Antoniou & Skopeliti 2015). Hence, new methods are emerging to assess and improve the quality of crowdsourced data, both during data collection and in post-processing afterwards (Fonte et al. 2015).

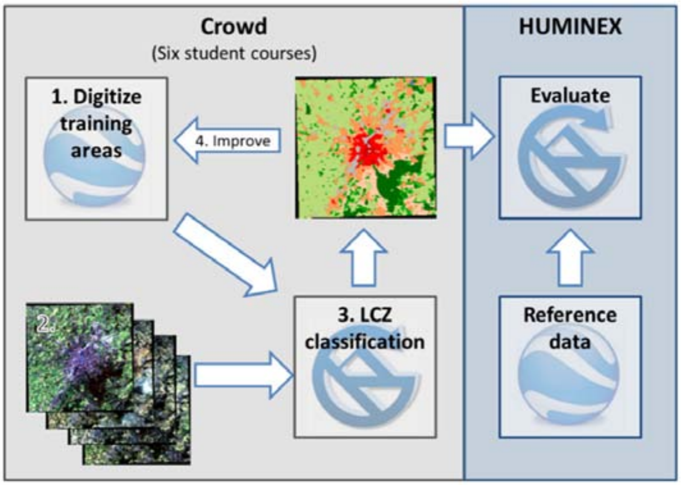


Figure 2. LCZ classification workflow (by operators) and HUMINEX evaluation (by authors of this study) (Bechtel et al. 2017)

HUMINEX: experimental set up

The experiment was set up as a coordinated effort among student courses from six universities, who created TAs and LCZ maps for ten different cities (Table 1). Participants were provided with materials (software, website, and papers) for their classroom exercises, which included the LCZ mapping workflow as described briefly above. In total, 94 TA sets were evaluated. In addition to the TAs and LCZ maps, comprehensive metadata was collected from each operator using a questionnaire.

Table 1. Participants and cities in HUMINEX 1.0. For AUG and TUB multiple operators were working on joint TA sets. Students from NOA additionally classified Hamburg, Madrid, Milan, Prague, Vienna, which were not included in the evaluation due to the small number of classifications per city (Bechtel et al. 2017).

Institute ID	Name	Number of Students	Cities Classified (Students)	Maximum Time for Completion	TA Sets Used in Evaluation
ASU	Arizona State University	7	Phoenix (7)	2 weeks (homework)	7
AUG	University of Augsburg	12	Augsburg (12), Vancouver (12)	homework	14
KUL	University of Leuven	31	Leuven (31)	9 h	28
NOA	National Observatory of Athens [a]	8	Athens (8)	homework	8
TUB	Technische Universität Berlin	14	Berlin (14)	2 days (16 h)	9
GU	Ghent University	28	Antwerp (4), Berlin (5), Brussels (5), Dublin (4), Ghent (6), Vancouver (4)	12 h	28

[a] Joint course with University of Peloponnese

Finally, some self-assessment questions were asked, including their assessment of the final LCZ map, their knowledge of the city being mapped, and their image classification experience.

Results and discussion

The analysis of the TAs and the classifications were performed in different phases. First, we compared the classifications of the same city to assess the impact of the operator on the classification result. Second, we conducted a class-specific analysis through the comparison with reference data to determine if some LCZ types were consistent and generally had higher accuracies than others. Third, we assessed the accuracy of the different iterations by diverse accuracy measures; and finally, the added value of combining multiple TA datasets to create a single LCZ map was assessed.

HUMINEX 1.0 showed that there are large differences between different LCZ maps generated for a single city. The consistency and accuracy measures indicated that the quality of single TA sets and the resulting LCZ maps was, in most cases, poor to moderate. Furthermore, differences were found between the cities, which can partly be explained by small differences in the experimental setup.

For many TA sets, the number of iterations was low, and sometimes only the final TA set was delivered. In most cases, the duration of the exercise was too short to perform iterations until the classification results converged to an acceptable result. Inter-city comparison was faced with some difficulties due to inconsistencies in the number and type of classes present in the different cities, domain size, and frequency distribution in reference data. High overall accuracy (OA) was for example mainly reached for coastal cities, since the LCZ type G (water) is comparably easy to detect and thus boosting the overall accuracy of the map. Such accuracy results underline the benefit of new accuracy measures based on the urban types, built-up and weight accuracy to minimise biased results due to large zones, which are easy to classify e.g. water. However, it remains a shortcoming of a non-stratified sampling approach that the accuracy measures may be biased towards some categories, which was addressed by careful selection, and checking of the reference data by multiple referees.

Overall, all results show that it is more difficult for untrained operators to identify correct TAs for LCZ mapping. Human interpretation is generally known as a difficult factor in remote sensing (Van Coillie et al. 2014) and crowdsourcing (See et al. 2013; See et al. 2016); some difficulties however are specific to the LCZ typology. The LCZ scheme is based on idealised types, which are not easily found in urban areas; the mixture of different heights and densities proves to be a hurdle for the untrained operators. Moreover, in some of the studied sites (e.g. Ghent and Brussels, Belgium) large homogeneous areas are hard to find, and the typical patches might be smaller than the neighbourhood scale (≤1 km^2). In addition, we found that some LCZs could be identified in the landscape without difficulty (e.g., LCZs A or G), while other categories posed problems resulting in lower consistencies and accuracies. LCZ 9 is urban, but has a built fraction of less than 20%, which is difficult to define given the Landsat 8 spatial resolution. LCZ E on the other hand can be either paved or natural stone, which makes little difference for the climatic impact but an enormous difference for settlement mapping. In most cases, these LCZ categories were also identified as 'hard to classify' by the operators, indicating that this question might be relevant for evaluating single LCZ classifications. Finally, the results showed that the recommendations for delineating TAs are often neglected or forgotten, resulting in TAs that differ from the instructions regarding size, shape and distance from other LCZs. In summary, it can be stated that: (1) operator knowledge is critical (hence the need for standardized training and assessment); and (2) independent controls (reference data or review by a trained expert) are necessary.

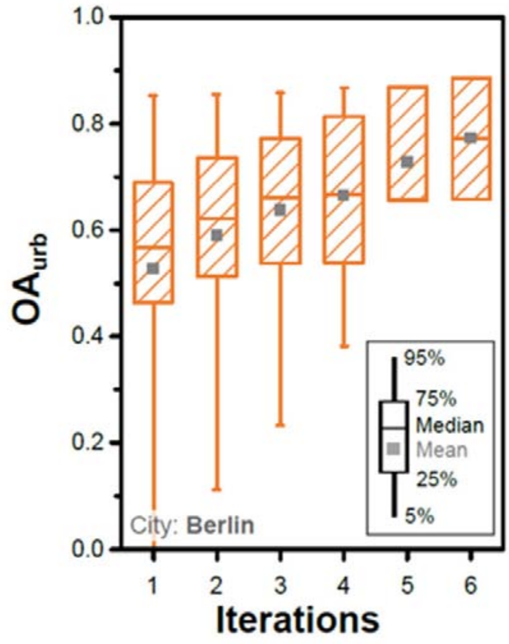


Figure 3. Results of different iterations: overall accuracy (OA) for Berlin, Germany (Bechtel et al. 2017)

However, even though some difficulties arose from using untrained operators for gathering crowdsourced data, the results also showed that the quality of the classifications clearly improved with the number of iterations (Figure 3), indicating that the existing WUDAPT protocol is a valid approach for LCZ mapping.

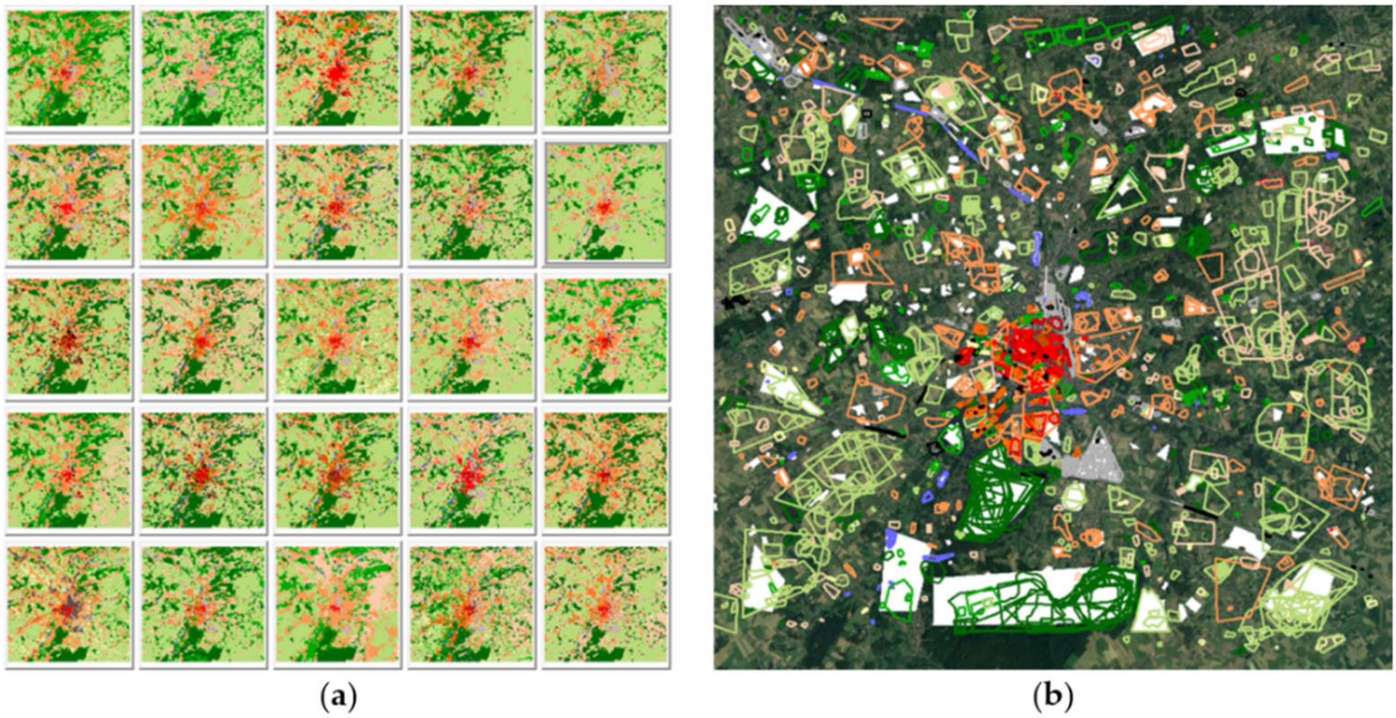


Figure 4. (a) Multiple individual classifications for comparison of accuracy measures and (b) the combined training areas from all participants to create a single LCZ map for the city of Leuven, Belgium (Bechtel et al. 2017).

Second, a striking and welcome finding was that considerable improvement of the LCZ maps could be achieved by combining multiple training datasets (Figure 4) from different operators. Despite the variable accuracy of individual LCZ maps, the aggregation of all TA sets of one city showed improved accuracy, which is evidence for the 'wisdom of the crowd'.

It was also shown that classifications using the mode of all available classifications or using multiple training data sets for one classification had higher accuracies than the mean accuracy of individual classifications of a city, and often even higher than the best one (Figs. 5 and 6). This was especially true for the urban LCZ types. Moreover, the dependency of the accuracy on the number of available sets showed a strong increase in the beginning, with saturation afterwards, indicating that TA sets from about 10-15 individuals could result in a good quality LCZ map. From these results, we conclude that at least ten individual TA sets should be used for one city to produce a good quality LCZ map, although this aspect needs further investigation.

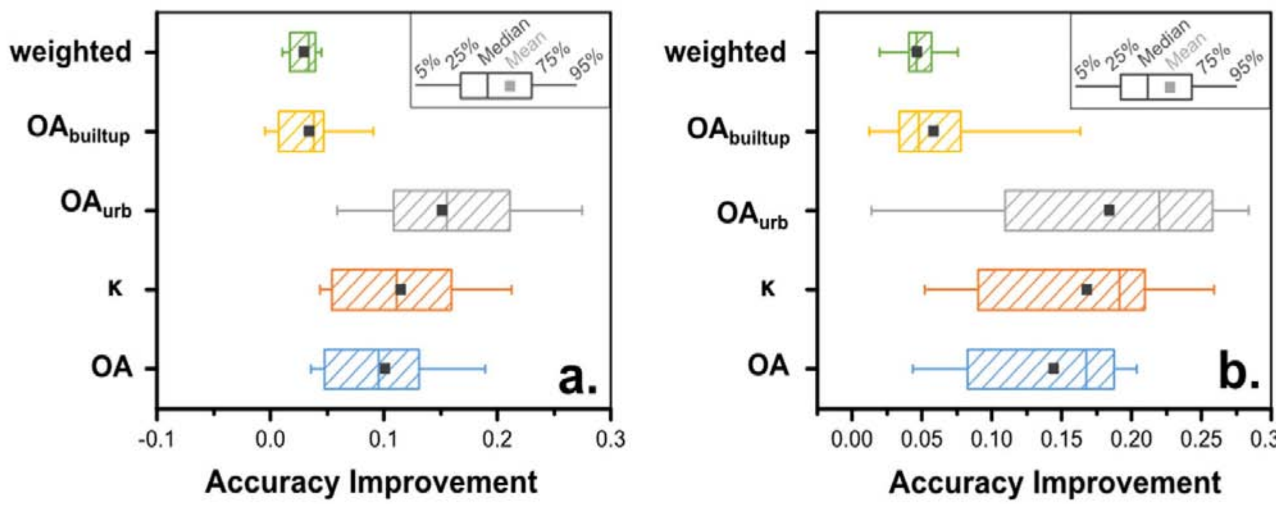


Figure 5. Improvements with additional training data: (a) modal type and (b) multiple training areas (TA) result vs average of individual TA sets. Distribution for ten cities (Bechtel et al. 2017). OA: overall accuracy, K: kappa

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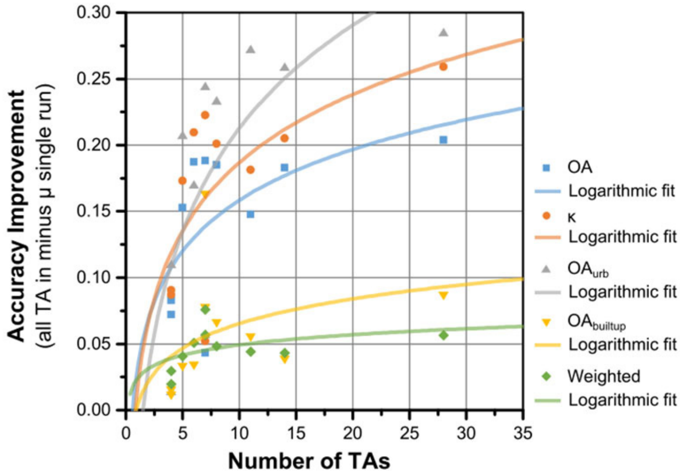

Figure 6. Dependency of the accuracy improvement on the number of available TA sets (Bechtel et al. 2017). OA: overall accuracy, K: kappa, μ: mean

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For participation in HUMINEX 2.0, we refer you to the WUDAPT website (deadline November 1, 2017):

http://www.wudapt.org/huminex-2-0/

Soil respiration across the greater Boston area; a substantial source of CO_2 to the atmosphere

Introduction

The explosion of the global urban population from 30% to over 65% between 1950 and 2050 (United Nations, 2014), the rapid physical expansion of urban areas (Seto et al., 2012), and the continued increase in the number of megacities worldwide (United Nations, 2014) has created urban hot spots for emissions of carbon dioxide (CO_2). Rising atmospheric CO_2 due to these emissions is the chief reason for the warming of our planet (IPCC, 2014). However, while cities are responsible for most of the world's fossil fuel CO_2 emissions ($FFCO_2$; Energy Information Administration, 2013), they may also present the most promising solution to the problem of climate change. For not only do cities contain the majority of the world's people and emit the most CO_2, but with smaller government machinery, cities also may present the greatest opportunity to enact broad measures to reduce global CO_2 emissions (Rosenzweig et al., 2010; Wang et al., 2012). We are already starting to see these developments take place through the numerous climate action plans in cities around the world and through climate initiatives like the global Compact of Mayors, which represents over 600 cities worldwide (Figure 1), and though the United States (US) has unfortunately withdrawn from the Paris Climate Accord, over 250 US cities have committed to meet or exceed the goals of the Accord (www.climate-mayors.org).

To determine whether climate action plans and other urban climate initiatives are having their intended effects, precise accounting of greenhouse gas fluxes and accurate measurements of urban atmospheric CO_2 concentrations are critical activities (Duren and Miller, 2012; Ryerson et al., 2013). In cities, this system of assessment, commonly referred to as MRV (Monitoring, Reporting and Verification), typically considers all CO_2 emissions to be derived from $FFCO_2$ (Kennedy et al., 2010). It has long been assumed that cities, with comparatively low plant biomass, large swaths of impervious area, and elevated $FFCO_2$ emissions, have negligible biological carbon (C) fluxes (Hutyra et al., 2014). However, there is a growing body of work that shows that the opposite is true in mesic and irrigated cities: the biology in cities is not only more robust than is assumed, but is actually quite important in terms of C fluxes (e.g. McKain et al. 2012, Hardiman et al. 2017).

Using the US state of Massachusetts (MA) as a case study, our group investigates the effects of urbanization on the biogenic component of the C cycle. The state of MA is a mix of urban and rural land covers, with the eastern portion of the state around the city of Boston more heavily urbanized than the rest of the state (Figure 2). Harvard Forest, a Long Term Ecological Research (LTER) site in Petersham, MA, provides a wealth of biological insight and a rural reference case. Early results from this body of work have shown that

Figure 1. Cities participating in the Compact of Mayors. (www.compactofmayors.org)

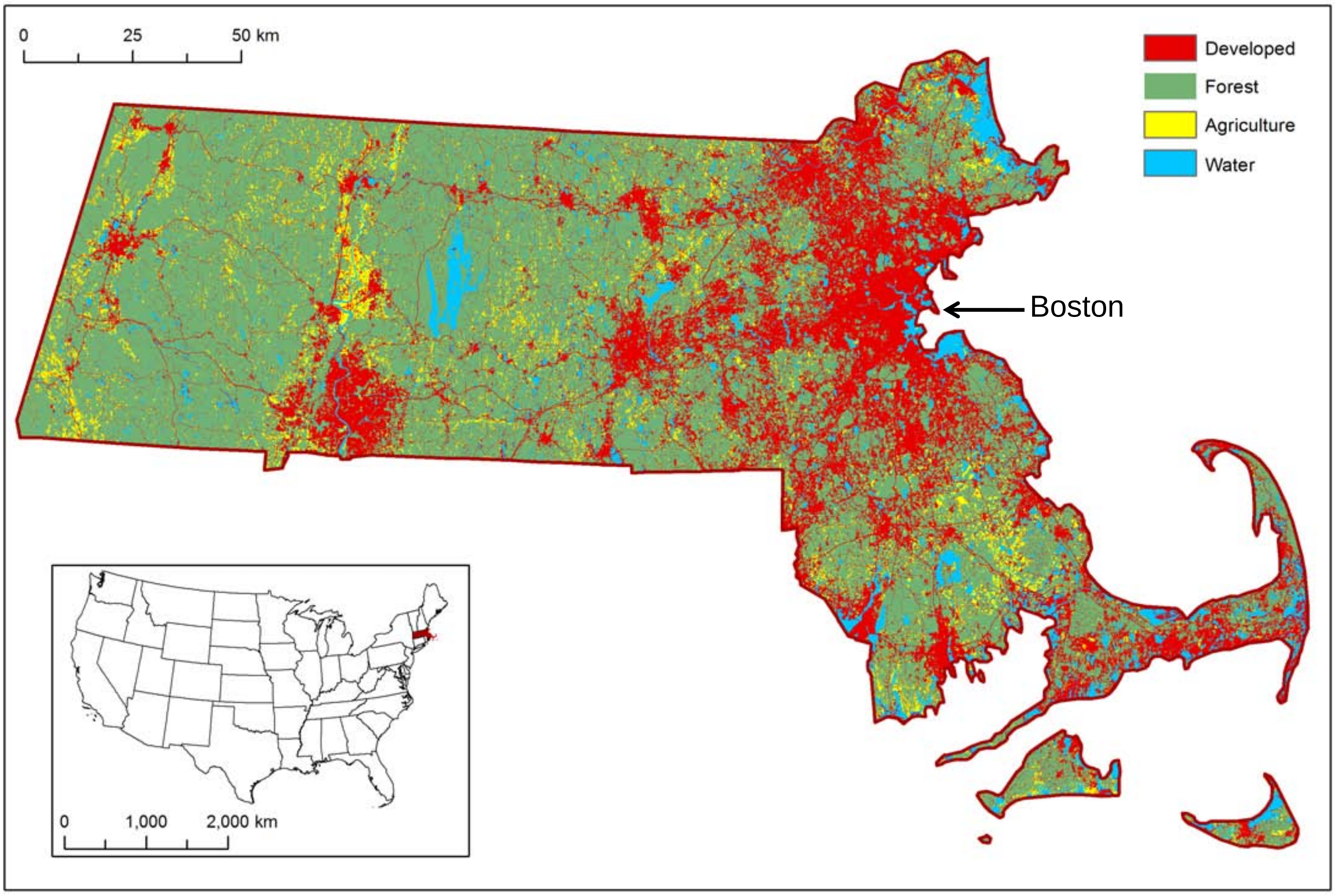

Figure 2. The State of Massachusetts (MA). Classification of land cover according to the National Land Cover Database (NCLD; Homer et al., 2015). Inset map shows the United States (US) with the location of the state of MA colored in red.

Boston's growing season is substantially longer than that of Harvard Forest, increasing the C sequestration potential of urban vegetation by 50% over that of rural vegetation (Briber et al., 2013). We also found substantially increased rates of nitrogen (N) deposition in the urban area around Boston compared to Harvard Forest (Rao et al., 2014), which may increase the strength of the vegetation C sink in Boston. In addition, we discovered that urban vegetation grows faster than rural vegetation, taking up and releasing C twice as fast per unit biomass as vegetation in rural areas (Hardiman et al., 2017). The rapid rate of C uptake by vegetation in the Boston Metropolitan area is due to the combination of longer growing season, increased N availability, higher temperatures due to the urban heat island (Wang et al., 2017), and increased light and nutrient availability from edge effects (Reinmann and Hutyra, 2017).

How urban growing conditions affect soil respiration fluxes is less clear. Increased N deposition, which is commonly seen in urban areas (Lovett et al., 2000; Pan et al., 2012; Rao et al., 2014) has been shown to diminish rates of soil respiration in rural areas (Janssens et al., 2010). On the contrary, one may expect to see elevated respiration rates due to the increased temperature of the urban heat island and the positive relationship between temperature and soil respiration (Lloyd and Taylor, 1994). However, we do not know the relationship between atmospheric N deposition and CO_2 fluxes in urban areas. Is urban soil respiration an important source of CO_2 to the urban atmosphere? Most studies that have measured urban soil respiration have generally included either few sites, only made measurements a handful of times, or both (Kaye et al., 2005; Groffman et al., 2006; Vesala et al., 2008; Groffman et al., 2009; Beesley 2012; Chun et al., 2014; Ng et al., 2014; Smorkalov et al., 2015), so these questions remain largely unanswered.

To address this gap in knowledge, we quantified rates of soil respiration at high spatial and temporal resolution across the urban area of greater Boston, MA, US. During the growing season (May 27 – November 5) of 2014, we took measurements of soil respiration at 15 sites (Figure 3) across the greater Boston area using an automated soil CO_2 efflux system. We used these measured rates, information from a local landowner survey, and geospatial data to create a spatially explicit model of soil respiration along an urban-suburban-rural transect. Finally, we put these respiration fluxes into an urban context by comparing fluxes of soil respiration to $FFCO_2$ in time and space. The following information is presented in greater detail in Decina et al. (2016).

Materials and Methods

Site selection and measurements – The Boston metropolitan area is the 10th largest metropolitan area in the US (US Census Bureau, 2013) and has a temperate climate. Mean summer and winter temperatures in Boston are 21.7 °C and -0.1 °C, respectively, and the area receives approximately 110 cm of precipitation annually (National Climatic Data Center).

Due to human disturbance, an ever-present problem with field sampling in urban areas is finding suitable locations for sites, particularly when equipment must be left in the field. To mitigate this problem, we located 14 of our 15 sites in protected backyards. The final site was hidden in an urban forest at Boston's Arnold Arboretum that receives little foot traffic. We chose sites with varying amounts of surrounding urban development. Within each site, there were three potential cover types: forest, lawn, and landscaped. Lawn cover type was defined as an area whose dominant vegetation was grass; 13 sites included the lawn cover type. Forest cover type was defined as an area at least 100 m in diameter whose dominant vegetation was trees and received no homeowner management; three sites included forest cover type. Landscaped cover type was defined as areas not covered by grass and generally contained flowers, shrubs, and trees that were confined to a small area of the property; 14 sites included the landscaped cover type. Landscaped cover types had variable management practices across sites, though all received some maintenance from homeowners.

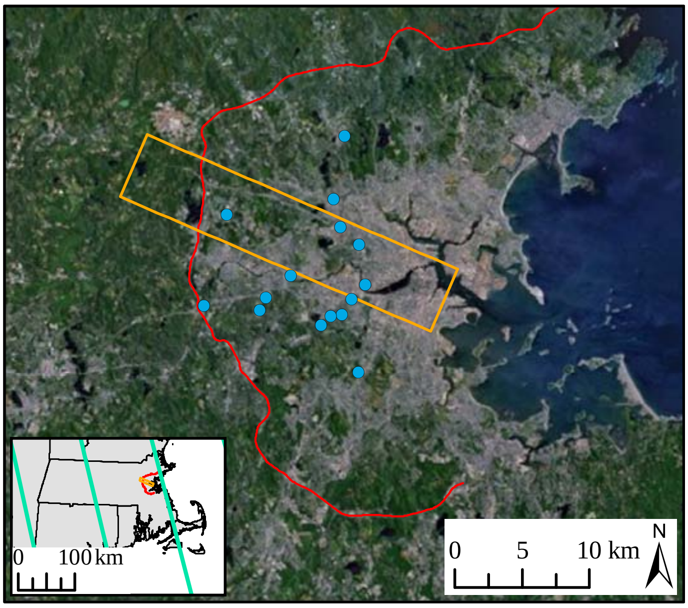

Figure 3. Study area. Blue points indicate measurement sites. Orange box outlines 25 km transect from downtown urban Boston to suburban Concord, MA (Figs 5A-D). Highway Interstate-95 is shown in red. Current NASA Orbiting Carbon Observatory 2 (OCO-2) summer nadir tracks are shown in the inset in green. Figure taken from Decina et al. 2016.

We measured soil CO_2 efflux every two weeks from 27 May 2014 to 5 November 2014 using an automated CO_2 soil efflux system (LiCor-8100A infrared gas analyzer, LiCor Inc.). Soil CO_2 efflux was calculated as given in Davidson et al (1998). At the time of measurement, we also measured volumetric water content at a depth of 10 cm and LiCor chamber air temperature. Measurements of air temperature, soil moisture, soil organic matter, soil C:N ratio, soil pH, soil bulk density, litter depth, and litter mass were collected in each cover type at each site. Summary data from these measurements are listed in Table 1.

Table 1. Litter and soil characteristics, along with soil respiration (R_s) CO_2 efflux, by cover type. OM = Soil organic matter; SE = Standard error. Table taken from Decina et al. 2016.

Cover Type	Sites (*n*)	Obs. (*n*)	Litter*			Soil						
			Depth (cm)		Mass (g)	OM (%)	pH	C:N	Bulk ρ (g cm^{-3})	Seasonal Mean R_s (μmolCO$_2$ m^{-2} s^{-1} ± SE)		
			June	Nov								
Forest	3	83	0.92	5.09	76.72	14	5.13	18.53	0.61	2.62	±	0.15
Lawn	13	292	0.63	3.88	1.64	8	6.28	16.06	0.88	4.49	±	0.14
Landscaped	12	309	3.00	5.86	63.67	15	5.88	18.68	0.64	6.73	±	0.26

* Leaf litter within a 900 cm^2 square adjacent to the collar

Survey data and Scaling Soil Respiration Efflux – We used data from a survey, the Community and Conservation Survey of Massachusetts (CCS), to estimate percentages of each cover type for residential properties and to ascertain usage of soil amendments such as fertilizer and mulch. The CCS was given to landowners in towns across eastern and central MA as well as to the 14 homeowners in this study (n=428). Homeowners were asked to estimate the fraction of their property with different land cover types as well as to describe land management practices.

In the model, all pervious (permeable) surfaces were assigned a soil CO_2 efflux value based on land use. The mean land cover type percentages from the CCS (lawn, forest, landscaped) were calculated and used to determine a mean residential soil CO_2 efflux rate of 5.33 μmolCO_2 m^{-2} s^{-1}. All areas covered with impervious surfaces, such as roads and buildings, were assigned a soil CO_2 efflux value of zero.

Fossil fuel carbon dioxide emissions – $FFCO_2$ emission estimates along the 25 km transect were based on a high-resolution regional inventory of $FFCO_2$ emissions made using data from the U.S. Environmental Protection Agency (EPA, 2014a) National Emissions Inventory, the EPA Greenhouse Gas Reporting Program (EPA, 2014b), and the Database of Road Transportation Emissions (DARTE; Gately et al., 2015). These $FFCO_2$ estimates represent direct, local emissions only; there are emissions outside of the transect associated with power generation for locations within the transect that were not included in our analysis.

Results and Discussion

Soil respiration rates differed (one-way ANOVA, F = 4.69, p = 0.019) between forest, lawn, and landscaped cover types (Figure 4), with the highest rates in landscaped areas, followed by rates in lawn and then forest (Table 1). Soil respiration rates in urban forest soils during the growing season were similar to rates in a nearby rural forest (3.08 ± 0.07 μmolCO_2 m^{-2} s^{-1}; Giasson et al., 2013), while lawn and landscaped soil respiration rates were substantially higher. Soil organic matter (r = 0.59, p = 0.0009), soil C:N (r=0.56, p=0.001) and leaf litter depth (r = 0.57, p =0.001) were positively correlated with measured soil respiration rates. We calculated a multivariate regression model of soil respiration rates which included soil C:N ratio, litter depth, a management indicator term (managed vs. unmanaged), and a cover type fixed effect term (forest, lawn, landscaped; R^2 = 0.79, p < 0.002). The correlation between soil and litter variables with soil CO_2 efflux and the elevated rates of soil respiration in landscaped

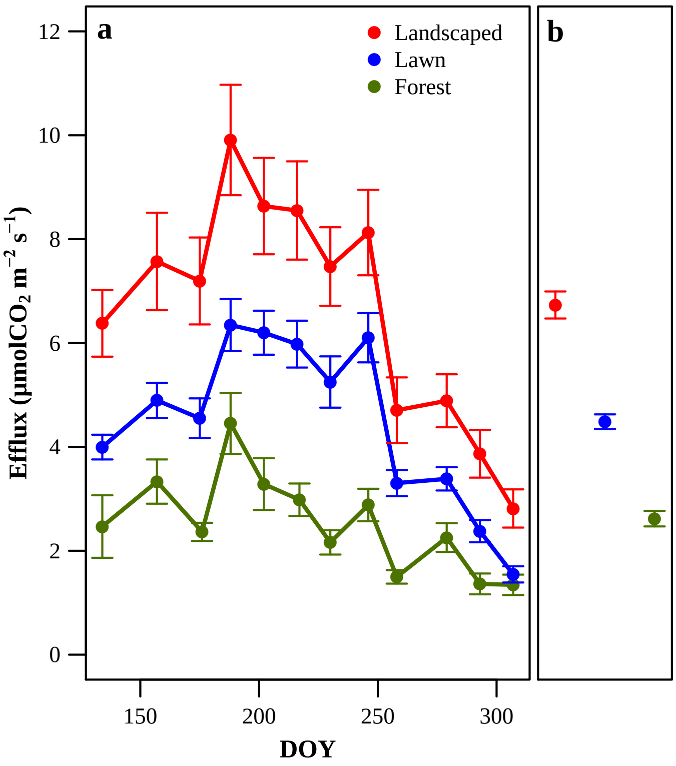

Figure 4. Measured soil respiration (R_s) CO_2 efflux by land cover type across growing season. (a) Means with standard error across fifteen sites at each date of measurement over the growing season (27 May 2014 through 5 November 2014). (b) Seasonal means and standard error by land cover type. DOY = Day of year. Figure taken from Decina et al. 2016.

areas indicate that the rates of urban soil respiration are strongly influenced by landowner management practices. Data from the CCS indicate that 90% of residential homeowners add organic amendments such as mulch to their properties, 64% fertilize their lawns, and 37% add compost or organic fertilizer to their plants. These management practices, which stimulate primary productivity and introduce labile C to urban soils, might explain the elevated soil respiration rates in residential areas as compared to rural background levels (Beesley et al., 2014; Chen et al., 2014).

Rates of soil respiration in residential areas are not only elevated as compared to rural reference rates, but also contribute substantially to urban atmospheric CO_2 concentrations on a landscape scale. Using GIS and survey data, we modeled our measured soil respiration rates across a 25 km transect originating in downtown Boston (Figs 5a-d), and compared this modeled soil CO_2 efflux to $FFCO_2$ emissions along the same transect (Figs 5e & 5f). In the highly developed urban core of Boston with little soil and high emissions, growing season soil CO_2 efflux is only about 1% of $FFCO_2$ emissions (Figure 5e). However, in the

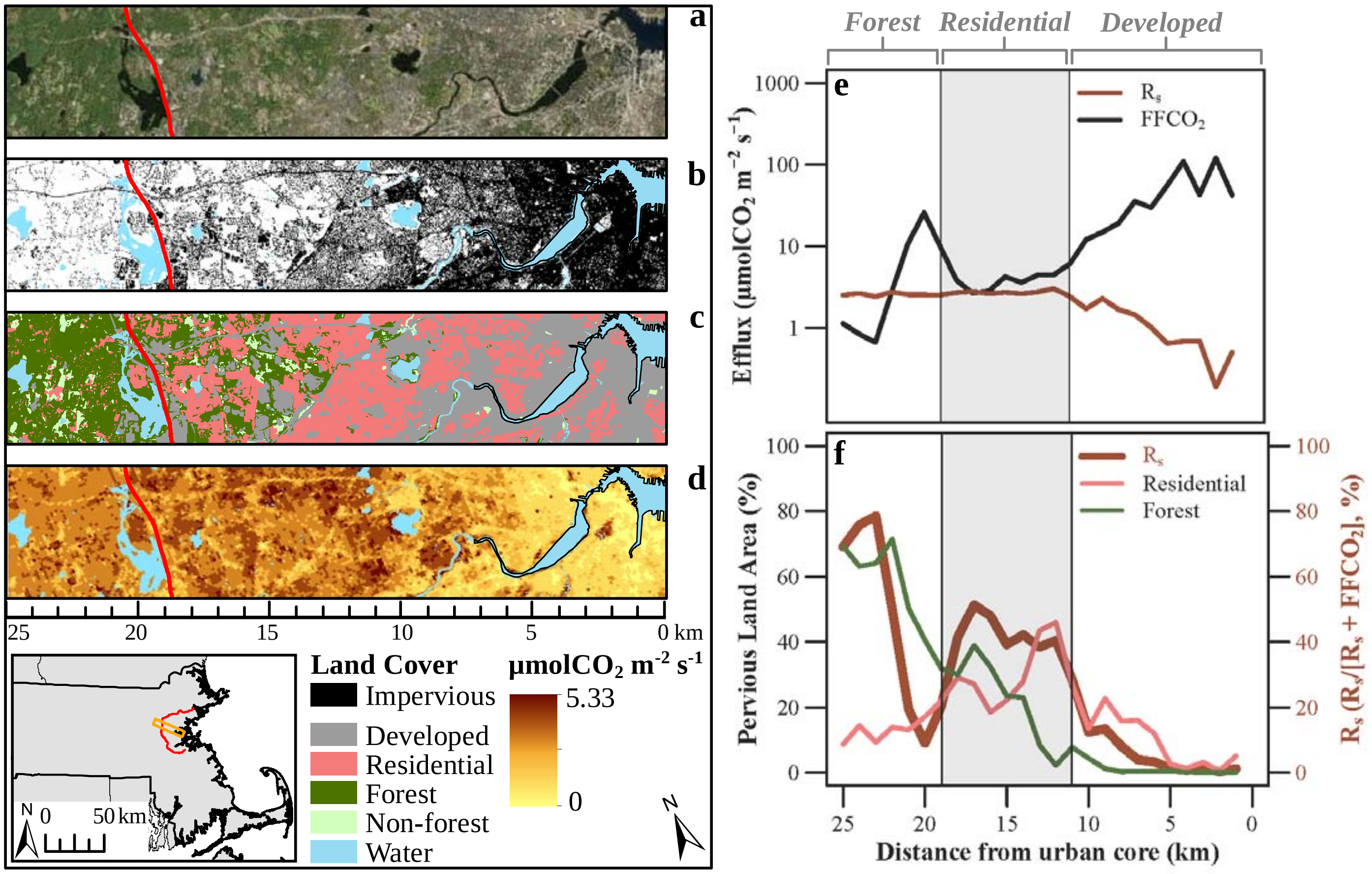

Fig. 5. Gradients in soil respiration (R_s) CO_2 efflux and $FFCO_2$ efflux along 25 km transect. (a) Satellite image, (b) Impervious surface area, (c) Land cover, and (d) Modeled growing season soil CO_2 efflux. (e) Growing season modeled soil CO_2 efflux and $FFCO_2$ emissions along the transect; $FFCO_2$ increase at 20 km due to Interstate-95 (red line in panels A-D is Interstate-95). Gray band (11-18 km from urban core) marks a shift from predominately developed to residential land covers. (f) Percent pervious forest and residential area compared to soil CO_2 efflux as a percentage of soil CO_2 efflux plus $FFCO_2$ emissions along the transect. Figure taken from Decina et al. 2016.

populous residential area of the transect 11-18 km from Boston's urban core, mean rates of growing season CO_2 efflux from soil respiration average 72±7% of $FFCO_2$ emissions (Figs 5e & 5f). Taking into account the extent of residential soils typically surrounding the urban core of many cities, these results highlight the connection between urban and suburban development, homeowner land management, and efflux of CO_2 from soil respiration in cities.

The amount of soil CO_2 efflux as a percentage of total urban CO_2 efflux varies temporally across the growing season as well. Soil respiration rates peak in the early summer, when conditions are most favorable for high respiration rates, while $FFCO_2$ emissions reach a minimum due to the absence of emissions from home heating (Figure 6). However, this pattern reverses in the colder months of May and October, creating a temporal mismatch in the maxima of soil respiration rates and $FFCO_2$ emissions. As the biogenic fraction of urban CO_2 emissions varies across the growing season, understanding not only the spatial patterns, but also the temporal patterns, of urban soil respiration is important to accurately measure and understand urban $FFCO_2$ emissions.

Conclusion

This study indicates that soil respiration produces substantial amounts of CO_2 in urban areas and that these rates exhibit distinct spatial and temporal patterns. Soil CO_2 efflux in urban areas is shown to be elevated in lawns and landscaped areas, perhaps as a result of additions of fertilizers and mulch by homeowners. On a landscape scale, the magnitude and spatial and temporal variation of urban soil CO_2 efflux should be taken into account when determining budgets of urban C, particularly for cities in temperate biomes with urban core surrounded by residential development with landscaped, pervious area. With satellites providing high resolution CO_2 column concentration data (Boesch et al 2011), understanding the biological contribution to urban atmospheric CO_2 concentrations is essential to interpret and make use of these data for evaluation of urban climate action plans. These results add to our body of work around the greater Boston area describing urban fluxes of C and emphasize the need for a more detailed accounting of fluxes of biological C across urban ecosystems.

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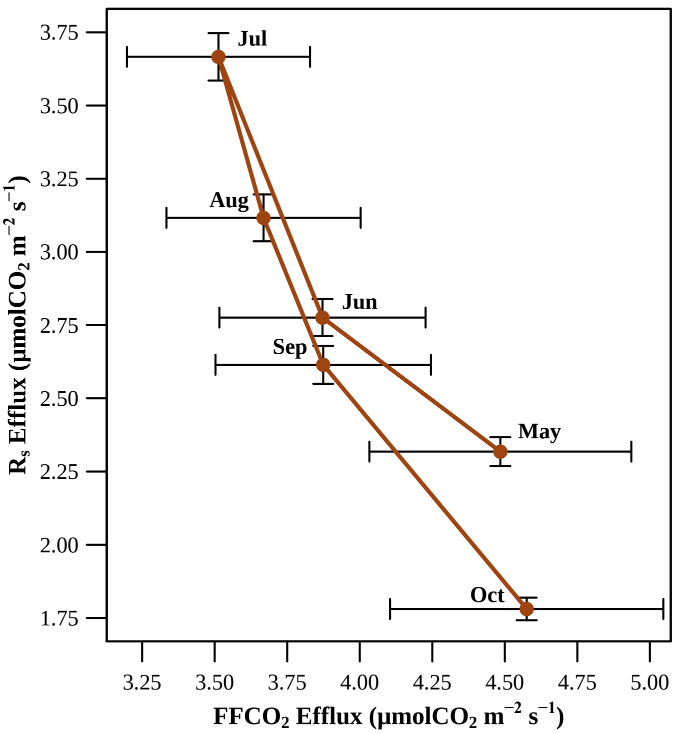

Figure 6. Monthly modeled soil respiration (R_s) CO_2 efflux as compared to modeled FFCO_2 efflux along 25 km transect. Monthly integrated mean values with standard error in the residential area from 11-18 km along the transect are used for both FFCO_2 and soil CO_2 efflux. Figure taken from Decina et al. 2016.

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Urban cooling from heat mitigation strategies: Systematic review of the numerical modeling literature

1. Context and objectives

Urban areas tend to be hotter than their non-developed surrounds, and they are projected to further warm over the 21st century due to global climate change and urban development (Georgescu et al. 2014). Without appropriate adaptation, higher temperatures in many cities are likely to have increasingly adverse effects on health, thermal comfort and energy consumption outcomes. While these outcomes have multiple causative factors, air temperature is strongly implicated in all of them and more widely studied than other urban climate variables. Intentional modification of urban landscapes can reduce air temperatures locally, and there is a burgeoning literature focused on numerical simulation of micro-to-regional scale climate effects of urban heat mitigation strategies (Gunawardena et al. 2017; Krayenhoff and Voogt, 2010; Santamouris 2014; Santamouris et al. 2016).

Urban heat mitigation simulation studies vary in terms of spatial and temporal scale, background climate, modeling assumptions, type and intensity of heat mitigation implementation, and climate response variable definition. As a result, the range of simulated cooling magnitudes induced by urban heat mitigation strategies varies widely; a recent review reports cooling that spans a full two orders of magnitude: <0.1 K to >5 K (Santamouris et al. 2016). Furthermore, key metadata, such as neighbourhood morphology, or the specific air volume associated with the reported climate response, are often unreported. Methodological quality becomes uncertain, and comparison among studies is rendered difficult.

An individual heat mitigation simulation or study tied to a particular place may be of great practical relevance to local planners and policy-makers. However, it must be situated among related studies if it is to inform the broader scientific understanding of the local climate impacts of heat mitigation strategies. Hence, a primary aim of urban heat mitigation research, in addition to assessment of local impacts, should be determination of consensus cooling efficacies for common heat mitigation strategies, as well as their dependence on a limited number of factors (e.g., meteorological conditions). To meet this objective, heat mitigation studies must be robust and comparable. We define 'robustness' as the trustworthiness of the results, based on scientifically sound, well-documented modeling methodology. 'Comparability' relies initially on full reporting of context (e.g., meteorology, urban zone) and methodological design (e.g., implementation type and intensity).

The intent of this systematic review is threefold:

- to assess the urban heat mitigation literature in terms of robustness and comparability;
- to derive an up-to-date consensus of cooling efficacies associated with implementation of common heat mitigation strategies from existing high quality studies in the literature;
- to recommend key methodological approaches and the reporting of essential metadata for enhanced robustness and comparability of urban heat mitigation studies.

2. Methodology

Defining "urban heat mitigation" – This review focuses on modifications to urban land cover or morphology, or urban facet properties, for the purpose of cooling local urban climate. All human-wrought changes to urban landscapes – synonymous here with the 'built' series defined by Stewart and Oke (2012) – made with the intention to reduce air temperatures within the urban canopy layer or at roof level are considered to be urban heat mitigation implementations for the purposes of this review. In most cases, "urban heat island mitigation" studies qualify, provided absolute urban cooling is reported in addition to relative cooling (e.g., urban heat island reduction). Urban heat mitigation implementations typically include one or more of the following: street trees, shade structures, reflective surfaces, greenery, permeable surfaces, or water features, applied at ground level, on rooftops, or on building walls (e.g., Fig 1; Table 1). They can also include modifications to neighbourhood configuration, including building morphology and street orientation.

Defining the literature sample – The literature sample is drawn from English language, peer-reviewed journal articles published between 1995 and March 2017. Pre-1995 urban heat mitigation studies applied models without explicit representation of vertical urban structure, and are therefore excluded. Previous reviews of urban heat mitigation studies document approximately 70 indexed, peer-reviewed studies that employ a numerical modeling approach (Krayenhoff and Voogt, 2010; Santamouris, 2014; Santamouris et al. 2016). The frequency of specific words and phrases from the abstract and keywords of these studies are used to derive a comprehensive yet targeted Web of Science search entry. From the ensuing literature sample, an article qualifies for the review sample by meeting the following criteria:

- Utilizes a numerical modeling approach;
- Employs a model that either yields a steady state solution, or has a prognostic temperature(s) –purely diagnostic and statistical models are excluded;

Figure 1. Example urban heat mitigation implementations.

• Simulates effects of urban surface or facet modification on urban canopy or surface layer air temperature cooling (studies that *exclusively* report other temperatures or indices are excluded; studies that do not include a 'base case' scenario are excluded).

The resulting sample includes more than 200 articles, employing models that vary from street scale to global scale, and from hourly to decadal time scales.

Criteria used to assess literature – Several criteria are developed to evaluate the robustness and comparability of existing urban heat mitigation studies. The following four criteria assess metadata reporting, required for effective comparison between studies:

• Site metadata are sufficiently detailed;
• Forcing meteorology is characterized;
• Heat mitigation implementation metadata are sufficiently detailed;
• Local climate response variable is fully specified, spatially and temporally.

Three subsequent criteria assess appropriateness of the numerical model and its application, which addresses the robustness of the modeling results obtained:

• Model representation of physical processes is sufficiently complete;
• Model evaluation is appropriately targeted and successful;
• Model is applied appropriately.

To date, these criteria (described briefly below) are based on the collective experience of the authors. Following Stewart (2011), each study is assigned a "pass" or "fail" grade for each criterion (Table 2); partial marks are available for some criteria. Grading is based exclusively on information provided in each peer-reviewed article. As such, complete and effective scientific communication is implicitly included as a criterion throughout the grading scheme.

(1) Site metadata are sufficiently detailed: Essential information about the surface structure, fabric, and cover of the neighbourhood or neighbourhoods to be modified is included (Oke, 2006), or the relevant local climate zones (Stewart and Oke, 2012) are identified.

(2) Forcing meteorology is characterized: The origin of the meteorological forcing of the urban atmosphere is identified, and its variation is characterized appropriately with respect to the temporal and spatial scales being investigated.

(3) Heat mitigation implementation metadata are sufficiently detailed: The nature of the surface modification is identified, and its horizontal, vertical, and temporal distribution is described (Table 1). Sufficient information is provided to assess the plan area average change of the modified surface variable(s).

(4) Local climate response variable is fully specified: To limit the scope, air temperature is the climate response variable chosen as the focus of this systematic review. Nevertheless, the ensuing discussion is largely relevant to other climate response variables. Heat mitigation modelers should choose one or more climate variables that best fit their purposes.

(4.1) Horizontal specificity – The specific horizontal area or location associated with the climate response variable is stated or implicit in the discussion, and its relation to the area modified by the heat mitigation implementation is apparent and appropriate (in general, the same as the modified area, or a subset).

(4.2) Vertical specificity – The level or layer associated with the climate response variable, and its relation to the urban canopy layer or mean building height, is

Table 1. Heat mitigation implementations organized by scale and physical processes modified.			
	Energy exchange processes directly altered	***Example implementations***	***Metadata to report (all that apply)***
Surface fabric & cover			
Radiative properties	Shortwave reflection, Longwave reflection & emission	Cool or reflective roof coatings	Albedo, Emissivity
Water availability	Latent heat flux (evaporation)	Low vegetation, Pervious materials, Water features	Pervious fraction, Irrigated/wet fraction, Vegetation type, Water depth
Thermal properties	Storage and release of heat via conduction	High thermal mass building walls	Thermal admittance, Facet thickness, Insulation thermal properties, Depth and thickness
Roughness	Turbulent transport of sensible and latent heat		Obstacle height, Obstacle density
Neighbourhood structure & cover			
Trees	Latent heat flux Heat storage	Street trees	Leaf area index, Plan area fraction of tree cover, Tree species
Buildings and other structures	Net shortwave and longwave radiation, Turbulent fluxes of heat and moisture, Heat storage	Shade structures, High height-to-width ratio for daytime shading, Street orientation aligned with prevailing winds	Plan and frontal area fractions, Street height-to-width ratio, Street orientation

Table 2. Points-based grading scheme for evaluating quality of literature on numerical modeling of heat mitigation implementation effects on urban climate, based on Stewart (2011).

Criterion	***Weight class***	***Maximum points allotted***	***Partial points***
(1) Site metadata	Desirable	1	No
(2) Meteorological context characterized	Desirable	1	No
(3) Heat mitigation implementation metadata	Critical	3	Yes
(4.1) Climate response variable specified horizontally	Somewhat essential	2	Yes
(4.2) Climate response variable specified vertically	Desirable	1	No
(4.3) Climate response variable specified temporally	Somewhat essential	2	No
(5) Model physical processes complete	Somewhat essential	2	Yes
(6) Model evaluation appropriately targeted & successful	Critical	3	Yes
(7) Model application appropriate	Critical	3	Yes
Total		***18***	

clearly specified, either explicitly or implicitly.

(4.3) Temporal specificity – The time(s) of day as well as averaging of the climate response variable over multiple hours, days, seasons, years or meteorological conditions is specified or apparent from the discussion and/or figures.

(5) Model representation of physical processes is sufficiently complete: A case is made for the appropriateness of the chosen model for the intended heat mitigation investigation. Major model limitations in relation to the processes linking the climate response variable to the heat mitigation implementation are acknowledged (e.g., a model that assesses the transpiration effects of trees but ignores other effects such as shading).

(6) Model evaluation is appropriately targeted and successful: The modelled climate response variable is evaluated, applying rigorous model evaluation procedures, at spatio-temporal scales and resolutions that closely relate to those used for assessment of the climate response to the heat mitigation implementation. A convincing case must be made that the model is capable of assessing the climate effects of the heat mitigation implementation; model errors must be of similar order of magnitude to, or smaller than, simulated heat mitigation-induced cooling.

(7) Model is applied appropriately: Key parameter assumptions related to the heat mitigation implementation(s) are reported, and appropriate initial and boundary conditions for surfaces and the atmosphere, as well as their source, are identified. It is clear that boundary and initial condition effects are minimized spatially and temporally where the climate effects of heat mitigation are being evaluated.

3. Discussion and engagement

The objectives and methodology described in Secs. 1 and 2 form the basis of a review article in preparation (Krayenhoff et al. 2018). Assessment of articles based on the criteria detailed in Sec. 2 is scheduled for August 2017. Prior to that time, we invite comments and input, which may be directed to Scott.Krayenhoff@asu.edu or Ashley.Broadbent@asu.edu. We are particularly interested to develop criteria for evaluation of the literature sample that will most effectively advance numerical simulation of urban heat mitigation cooling efficacy. Particular questions readers are invited to consider and provide feedback on include:

1. What is the *scientific* goal of undertaking urban heat mitigation research?
2. How can the criteria for evaluation of the literature sample in Sec. 2 be improved?
3. How can the grading scheme in Table 2 be improved?

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Green Infrastructure: Nature-Based Solutions for Sustainable and Resilient Cities

European collaboration focusing on urban forests culminates in worldwide spring gathering

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The European COST Action FP1204 *GreenInUrbs* celebrated the conclusion of its four-year project with a final conference in historic **Orvieto, Italy** from April 4-7, 2017. The Conference scope and objectives were captured in the summary offered by Carlo Calfapietra, Conference and *GreenInUrbs* Chair:

> *"The quality of life in European cities and in most of the world is suffering due to rising pollution levels, intensified heat islands, loss of biodiversity, as well as flooding and extreme events related to climate change. This can have detrimental effects for human health and well-being. At the same time, cities are a large source of carbon and only a few attempts are underway to improve carbon sequestration at the local level. Green Infrastructure (GI), with a particular focus on Urban Forests, can contribute to the improvement of the urban environment through a number of mitigation actions. This is especially valid for the tree component of vegetation due to its larger biomass and extended canopies.*
>
> *…The main objective of the Conference is to show how a trans-disciplinary approach to urban planning based on GI as Nature Based Solutions will enable us to maximize the provision of Ecosystem Services, making future cities more resilient and sustainable. It will enable different communities, including researchers and academics, practitioners, policy makers, administrators and the private sector to exchange knowledge and insight."*

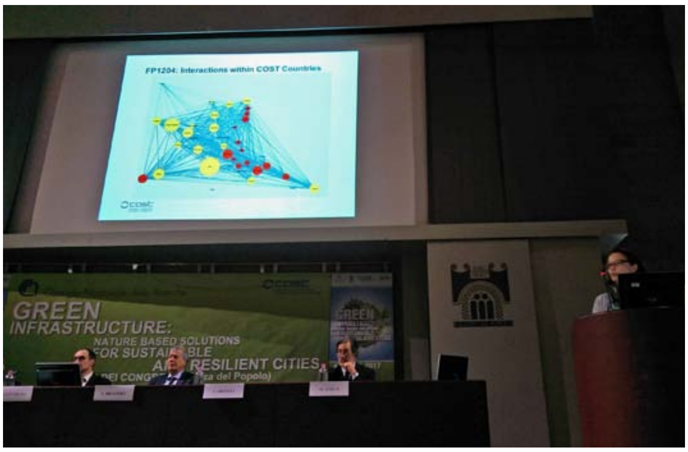
The Conference provided a wonderful opportunity for international dialog. It enabled the extensive community of *GreenInUrbs* project members, accompanied by many additional researchers, members of academia, decision makers as well as the private sector and practitioners from diverse Urban Forest-related professions, to capture accomplishments and explore the critical necessities for the European Urban Forest's future – creating sustainable, livable urban ecosystems.

In addition to debuting the just-published project book, *The Urban Forest: Cultivating Green Infrastructure for People and the Environment* (available at springer.com), along with a Guideline for Urban Forestry as Critical Green Infrastructure in European Urban Areas, the conference featured a broad range of keynotes, oral presentations and poster sessions. These sessions ran the gamut of nature-based solutions from sustainable management strategies of Green Infrastructure and their economic impact to the vast array of Ecosystem Service-related benefits that a healthy Urban Forest can afford its residents including air quality, health, thermal comfort, water management and cultural and environmental diversity.

The sustainability and livability of our ever-expanding urban centers will depend on our ability to address the impact Climate Change is having on our urban environment. As I sit here in Lucerne, Switzerland, drafting this report, experiencing weather that would normally be considered an anomaly in this place, at this time – in the mid 30's with no rain for over two weeks – and reflecting on the fact that this is no longer an anomaly but the new norm, the importance of the related Orvieto sessions seems ever more prescient.

Under the umbrella of "thermal comfort", a major contributor to urban heat stress is the ever-increasing amount of impermeable surface – as well as urban planning and design that have not yet embraced the growing body of knowledge on how to reduce the UHI and be more adaptable to climate-change. We have a number of tools at our disposal to mitigate these problems, as exemplified by the following sampling of presentations:

• **The green cover of city ecosystem-green roof** (presented by Elif Satiroglu, a Landscape Architect in Vienna, Austria) discussed the relationship between urban population growth and impervious surfaces in terms of its impact on urban land use. "Concepts such as Integrated Urban Water Planning, Water Sensitive Urban Design, Urban Water Efficiency Planning and Rainwater Management Approaches have proposed scientific approaches for solutions" to this problem. The presentation focused on "the climatic and ecological effects and design and examples of the Green Ripples used to direct, slow down and refine rainwater as Rainwater Management Systems".



The COST Action generated a vast network of connections between partners from every corner of Europe, around the environmental, social and governance issues related to urban forests and green infrastructure.

Following the conference, attendees traveled to Rome for a guided tour of the Villa Borghese gardens.

• **Hydraulic behavior of expanded cork agglomerate in green walls and living facades** (presented by Andreia Cortes, Department of Civil Engineering, University of Coimbra, Portugal) discussed the fact that "green walls and living facades may offer extensive benefits to cities, since they have the desirable potential to reduce the urban heat island effect, improve air quality and restore biodiversity… Expanded cork agglomerate is an environmentally friendly material with improved features of water retention and thermal insulation (which could) enhance the performance of green walls and living facades…"

• **Urban green infrastructure (UGI) as a tool for mitigating the urban heat island (UHI) – a review of methodologies** (presented by David Pearlmutter of Ben-Gurion University, Israel) provided "a survey of research approaches and findings of 90 studies which deal with the contribution of UGI to UHI mitigation and human comfort, in Mediterranean, Atlantic and Boreal climatic regions in Europe and Israel. The reviewers observed that "For optimal benefit from UGI research there is a need to study the combined effect of various green measures: vegetated terrain, green walls and in particular street trees and urban forests, as well as analyzing their applicability to urban planning and the translation of general principles into a set of practical rules for city planners and UGI managers."

• **The role of green infrastructure on urban climate – insights from the Copernicus Climate Change Service** (presented by Jorge H. Amorim, Swedish Meteorological & Hydrological Institute) was "interested in knowing how, and to what extent, urban planning affects the city's response to the climate signal. …In this work, results for a 5 year period over Stockholm, Sweden and preliminary outputs for Bologna, Italy are shown… By delivering high resolution urban climate data over European cities, Urban SIS aims at providing news insights into the potential of Nature Based Solutions to deliver innovative solutions for adapting to climate change. "

• **Planning for cooler cities: A framework to prioritize urban green infrastructure** (presented by Nicholas S.G. Williams, School of Ecosystem and Forest Sciences, University of Melbourne, Australia) discussed how "…the strategic implementation of urban green infrastructure (UGI) e.g., street trees, parks, green roofs and facades can help achieve temperature reductions in areas while delivering diverse additional benefits such as pollution reduction and biodiversity habitat…" and offered a "framework for prioritization and selection of UGI for cooling."

• **Quantifying the microclimate effects of urban green infrastructure for climate change mitigation and adaptation** (presented by Teresa Zölch, TU München Centre for Urban Ecology and Climate Adaptation, Germany) aimed at "…quantifying GI measures at an urban micro-scale with benefits for outdoor as well as indoor thermal comfort and building energy demand by coupling microclimate modeling with thermal building simulation… The methodological approach was tested for an urban block in Munich, Germany, representing a typical urban fabric of residential buildings with a high degree of compactness and surface sealing."

• **Assessment of the microclimatic impacts of urban green infrastructure based on local climate zone classifications** (presented by Parisa Pakzad, Faculty of Built Environment, UNSW Corporative Research Centre for Low Carbon Living, Sydney, Australia) stated that "Urban planners and landscape architects need detailed information about the thermal conditions of open spaces for their design decisions. The urban microclimate is a key factor for the livability and sustainability of a neighborhood. It is unique in any given location as it is mainly dictated by the diverse nature of the local physical environment, which alters the overall climate of the region. The microclimate at the street and neighborhood level can vary greatly within relatively short distances because of differences in solar exposure, wind speed, humidity, and air and surface temperatures. The overall thermal comfort of the environment determines the functionality of a space and its use by humans. In this study, a method is proposed to quickly assess the urban microclimate in relation to green infrastructure typologies at the local scale…and provides a set of planning recommendations in the form of a reference framework…"

• **Urban Trees – cooling down the heat island: Do species matter?** (presented by Anna Brähler, Strategic Landscape Planning and Management, School of Life Sciences, Weihensephan Technische Universität München, Germany) discussed their experiment "to clarify the impact of the cooling effectiveness of two common urban street tree species, *Tilia cordata* and *Robinia pseudoacacia*, on vertical and horizontal temperature profiles in the urban canopy layer (UCL). The project investigated the cooling performance of 20 individuals, during the summer of 2016 in Munich, Germany. Not only tree morphology and transpiration were measured, but also micro-meteorological variables, such as air and surface temperatures."

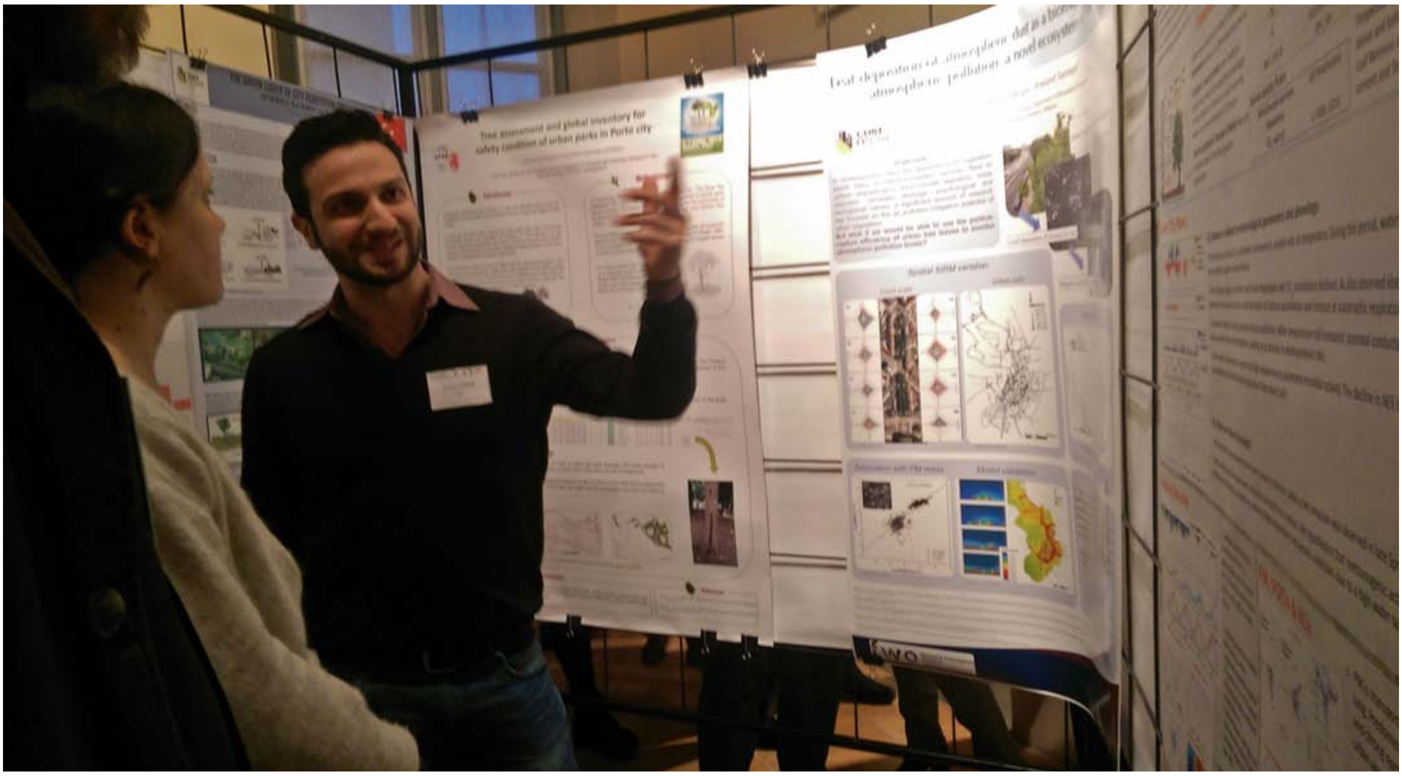
In reviewing the entirety of the COST Conference's presentation offerings, it is clear that diagnosing "thermal discomfort" and its vast array of contributory urban stressors will require an expanded collegial approach to disseminating and implementing the many strategies and resulting tools that are presently available. The cost effectiveness of a Nature Based Solutions approach clearly warrants such an effort.

All Keynote, Oral and Poster Presentation Abstracts, including those referenced in this report, can be found in the Conference's Book of Abstracts at http://www.greeninurbs.com/wp-content/uploads/2017/04/book_of_abstract.pdf.

More information about COST Action FP1204 can be found at http://www.cost.eu/COST_Actions/fps/FP1204 and additional information on the *GreenInUrbs* project component can be found at http://www.greeninurbs.com.

Ahmed Alhuseen of the Global Change Research Institute in the Czech Republic received the Award for "Best Presentation" for his work on the choice of public green spaces among residents of Khartoum, Sudan.

An extensive series of sessions was devoted to the role of urban green infrastructure in providing local climate regulation and enhancing climate change resilience.



The conference attracted over 400 participants from around the world and was packed with three full days of discussion, including poster sessions as well as oral presentations on green infrastructure topics ranging from heat mitigation to sustainable urban governance.

"...a major contributor to urban heat stress is the ever-increasing amount of impermeable surface – as well as urban planning and design that have not yet embraced the growing body of knowledge on how to reduce the UHI and be more adaptable to climate-change."

Photos: D. Pearlmutter

Joint Urban Remote Sensing Event (JURSE) held in Dubai

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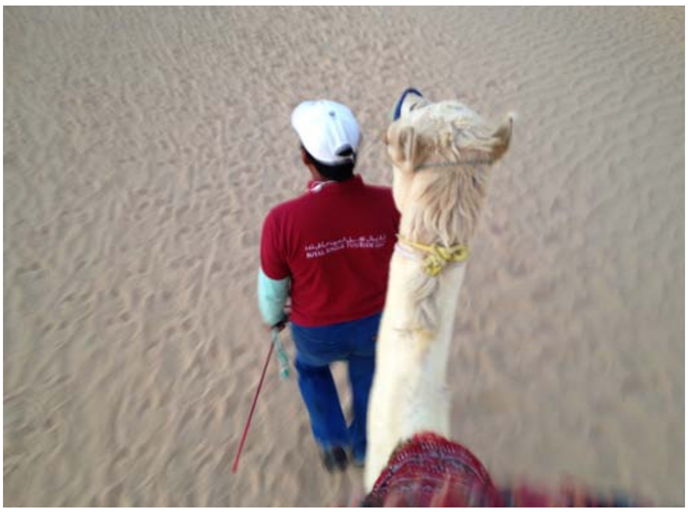
Colloquially known as the "jewel in the desert", the gleaming specular urban space of Dubai quickly disappears to a matte tan desert only a few miles outside the city, where the sea/land breeze cycle and occasional sandstorms slowly merge sand and asphalt. This bustling, slightly chaotic, and tremendously hot city served as the backdrop for the Joint Urban Remote Sensing Event (JURSE) held in March of 2017.

Jointly organized with the GIS and Remote Sensing Annual Scientific Forum, JURSE featured three days of sessions on a wide range of remote sensing and GIS topics, all largely under the urban umbrella. The sheer breadth of content on offer made clear the cross-discipline importance of spatial data about the form and function of cities – not only in study of the climate and ecology of cities, but also for informing urban planning, infrastructure, and social policy. Even across these somewhat disparate threads, use, adaptation, and critique of the Local Climate Zone (LCZ) framework featured prominently, in addition to other more ad-hoc urban classification methodologies.

Opening keynote addresses, from Peter Wonka of King Abdullah University of Science and Technology and Noel Gorelick of proper noun Google, provided a fitting bookend for the conference, each speaking on the development of machine learning techniques for generating and processing spatial and remote sensed data about cities – an additional third keynote was delivered on day three by Qihao Weng that addressed some key questions that face the use of time series analysis of remotely sensed data for urbanization studies.



Riding a camel in the Arabian Desert. Photo by the author.

The sail-shaped Burj Al Arab Jumeirah, a five star hotel built on an artificial sandbar. In the background is the Burj Al-Kalifa, obscured by a dusty haze on the horizon. Photo by James Voogt.

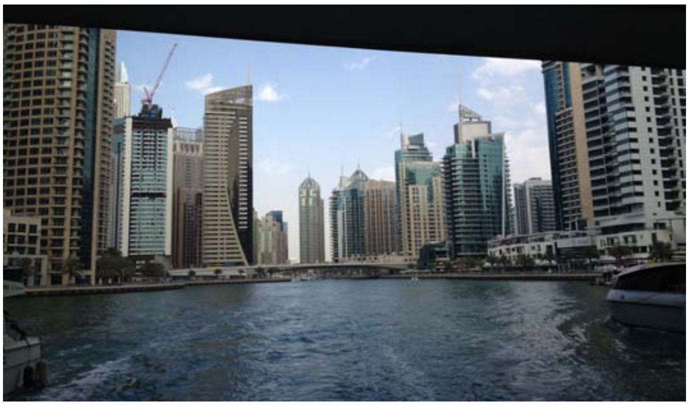
Challenges and applications in urban thermal remote sensing were featured in a pair of sessions chaired by Benjamin Bechtel and Iphigenia Keramitsoglou, with particular focus on linkages between urban morphometry and characterization of thermal climates in cities. In the first session, a presentation by Jan Geletič highlighted application and evaluation of LCZs in statistical analysis of remotely sensed land surface temperatures (LST) in Brno & Prague, Czech Republic, where seasonality was observed in both interurban variations in LST and relationships between LCZs and LST. A presentation by Yu-Cheng Chen used remotely sensed LST to infer spatial patterns of urban air temperature based on an LCZ classification of the Taipei Basin via relationships retrieved from vehicular traverses. Taking a slightly more cautionary tone, a presentation by James Voogt & Scott Krayenhoff used modelling tools to quantify the magnitude of urban effective thermal anisotropy for a range of LCZs, which indicate significant directional biases in thermal remote sensing of common urban morphologies. Similar discussion continued in a second session in which Paul Alexander explored seasonality in LST in Dublin, Ireland, highlighting the importance of climatological analysis (rather than single "snapshot" characterizations), when inferring relationships between urban form and LST. These sessions highlighted both the importance of the urban surface in determining urban thermal climates and difficulties and shortcomings still to be addressed in thermal remote sensing of urban environments, calling for an increased focus on critical and climatological assessments of the relationships between urban form, function, and LST.

A session on remote sensing of urban heat fluxes chaired by Nektarios Chrysoulakis and Christian Feigenwinter complimented and expanded on these threads.

Talks stressed the importance of integrating in-situ and remote sensed urban flux measurements with modelling tools for energy balance closure, to develop methods for estimation of inferred (rather than measured) heat fluxes, and to aid in evaluation of urban heat mitigation strategies. Mattia Marconcini discussed the need for urban-scale energy balance assessment in cities – particularly of anthropogenic heat fluxes – as spatial variation in urban form and function can lead to large errors in estimation of fluxes that cannot be measured directly. Ahmad Al Bitar spoke on an alternative method to estimate urban energy balance components at micro-scales utilizing thermal remote sensing and a 3-dimensional coupled radiative transfer and energy balance model.

Frieke Van Coillie and Frank Canters chaired a session on the "Urban Ecosystem Analysis supported by Remote Sensing" project (UrbanEARS), expanding the purview of urban thermal remote sensing outside of traditional climatic assessment. Benjamin Bechtel discussed successes and shortcomings in large-scale satellite based LCZ classification, highlighting sources of error from both human influence in manual classification and in the cross-city transferability of training areas - ultimately calling for the development and integration of new methods to aid in more accurate LCZ classification. Marie-Leen Verdonck evaluated thermal differentiation between LCZ classes in Brussels, Antwerp, and Ghent via a comparison between air temperatures from in-situ measurements and a time series of modelled data. Good agreement between both modeled and measured temperatures and large thermal differentiations between LCZ classes may indicate that these methods could be useful for evaluation of LCZ classification in similar cities.

Down an alleyway in one of Dubai's many souks (a street market formed by a narrow maze of alleys lined with open-air storefronts). Buildings in older parts of town often have rooftop windtowers (called "Al Barajeel", pictured) to aid ventilation. Photo by James Voogt.



Emerging from under a bridge on a ferry ride through the Dubai Marina. Photo by the author.

Often, the most fruitful discussion was prompted by talks with a more critical bent or from sessions that facilitated greater discussion. Given widespread usage of the LCZ framework across disciplines, James Voogt reminded the audience of the explicit and intended purpose of the framework. Indicating that although the LCZ framework may have many uses outside of identifying homogenous source areas in cities for making neighborhood scale measurements, a different classification scheme may be more suitable for study of other climatological variables (such as heat fluxes) or in other disciplines. Moreover, Zina Mitrika prompted a discussion of the representativity of certain LCZs – particularly densely built downtown zones – which often do not form coherent patches. This fact may prompt the need for more nuance in the LCZ framework to include mixed or irregularly shaped LCZs. This point is particularly appropriate given the venue (Dubai), where the city is made up of largely high rise buildings built in a thin strip along the coast.

Outside of academic discussion, the conference broke daily for a buffet-style lunch held on a semi-open-air pavilion at the back of the hotel. Beyond the pavilion is a maze of foliage-lined pathways leading to the sea. Most (read: nearly all) beaches in Dubai are private, but restrictions feel slightly more optional for grad students that can fake enough confidence to pass as an expat. The 830-meter Burj Al-Kalifa, the tallest building in the world, is just visible from the edge of the hotel beach. Its spire dwarfs the surrounding skyline and stands as a testament to the immense, and ever increasing complexity of the city – a sentiment, no doubt, reflected at large in cities across the globe. Indeed, as the Earth's urbanized population continues to increase, and cities grow and develop – both upward and outward – in response, tools to understand and interpret that growth and the brainpower to do so developed at conferences such as JURSE, will only increase in value.

Information about the conference can be found at http://www.jurse2017.com/index.html. Proceedings can be found at: http://www.ieeeexplore.ws/xpl/mostRecentIssue.jsp?punumber=7919506.

Recent Urban Climate Publications

In this edition a list is presented of publications that have generally come out between **March and May 2017**. 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. In order to make the lives of the Bibliography Committee members easier, 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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Upcoming Conferences...

21ST INTERNATIONAL CONGRESS OF BIOMETEOROLOGY
Durham, U.K. • September 3-7, 2017
http://community.dur.ac.uk/icb.2017/

CLIMATE AND CITIES CONFERENCE
Potsdam, Germany • September 19-21, 2017
http://ccc.ramses-cities.eu

PAN-EURASIAN EXPERIMENT (PEEX) 3RD SCIENCE CONFERENCE
Moscow, Russia • September 19-22, 2017
https://www.atm.helsinki.fi/peex/

14TH INTL. CONFERENCE ON URBAN HEALTH
26-29 September 2017 • Coimbra, Portugal
http://www.icuh2017.org/

INTERNATIONAL CONFERENCE FRIENDLY CITY 4
Sumatera Utara • Indonesia, October 11-12, 2017
http://www.friendlycity.usu.ac.id/

DRYLANDS, DESERTS AND DESERTIFICATION: COMBATING DESERTIFICATION AND DRYLAND MANAGEMENT – THEORY AND PRACTICE
Sede Boqer Campus, Israel • November 6-9, 2017
http://in.bgu.ac.il/en/desertification

AMERICAN GEOPHYSICAL UNION (AGU) FALL MEETING
New Orleans, USA • December 11-15, 2017
https://fallmeeting.agu.org/2017/

AMERICAN METEOROLOGICAL SOCIETY (AMS) ANNUAL MEETING
Austin, USA • January 7-11, 2018
https://annual.ametsoc.org/2018/

ICUC10: August 6-10, 2018 New York, New York

First Call for Abstracts

The 10th International Conference on Urban Climate (ICUC10), jointly with the 14th Symposium on the Urban Environment (SUE) of the American Meteorological Society (AMS), will be held August 6-10, 2018 at the historical campus of the City College of New York of the City University of New York in the Upper West Side neighbourhood of New York City.

The conference theme is ***Sustainable and Resilient Urban Environments***. The event is hosted and co-organized by the NOAA CREST Institute of the City University of New York, The International Association for Urban Climate (IAUC) and the AMS Board on the Urban Environment. ICUC10 is also supported by international organizations including the World Meteorological Organization (WMO). ICUC10 comes at a time when accelerated urban development is challenged by the risks and consequences of extreme weather and climate events and global socio-economic disparity. Resiliency and reduced vulnerability to all socio economic sectors have become critical elements to achieve sustainable development. ICUC10 will be the premier forum for these discussions.

The conference format will include: workshops, key note speakers, concurrent technical sessions, and discussion panels. Planned session-themes will include emerging and traditional topics in urban climate including, but not limited to, the following topics:

Extreme Weather in Cities

- Advances in weather forecasting for cities
- Storm surges modeling and prediction
- Tropical and extra-tropical storms in cities
- Modeling and observations of urban flooding
- Modeling and observations of extreme heat events in cities
- Emergency management for extreme weather in cities

Climate change mitigation & adaptation in urban environments

- Modeling and detection of climate changes in cities
- Intersections of climate change and land use for urbanization
- Mitigation and adaptation strategies for climate changes
- Climate information services for cities

Studies of urban climate and processes

- Boundary layer and canopy layer urban heat islands

http://icuc10.ccny.cuny.edu/

- Surface and subsurface urban heat islands
- Surface energy and water balances
- Flows and dispersion in the urban canopy layer
- Precipitation/fog/clouds
- Air quality/aerosols/radiative transfers in the urban boundary layer
- Influence of urban vegetation

New observational and modeling techniques and methods to study urban climates

- Field campaigns, sensor and networks development
- Satellite remote sensing of cities
- Wind tunnel & hardware model experiments
- Statistical models
- CFD/LES/Dispersion model
- Urban canopy parameterizations
- Urban databases and linkages with models
- Big data for urban climate studies

Bioclimatology and public health

- Outdoor microclimate and human comfort
- Indoor human comfort & air quality
- Human perception
- Health impacts of extreme weather events in cities

Transfer of urban climate knowledge

- Indicators and climate maps
- Storm surges and flooding maps
- Warning and communication plans for emergency response in cities
- Public policies that incorporate urban climate and processes
- Greenhouse reduction policies for cities
- Urban climate education

Urban design and planning with climate

- Buildings and urban climate
- Energy supply and demand in cities - the role of urban climates
- Sustainable design practices
- Morphological urban design
- Governance challenges for tackling urban heat

• Design of smart neighborhoods and cities
• Design for resiliency

Interdisciplinary topics

• Eco-system services and urban environments
• Socio-economics aspects of urban climate

Proposals for additional program suggestions are encouraged, please contact the program chairs to submit proposals for special sessions of interest.

Deadline for abstract submission for technical papers or special sessions is **15 December 2017** using the Conference web page. Outstanding oral and poster student presentations will be recognized at the conference.

Submission Deadlines

Opens: Wednesday, August 1, 2017

Closes: Friday, December 15, 2017
23:59 pm Eastern US Time

Notification: Early February 2018

Helpful Information

Abstracts for the 10th International Conference on Urban Climate need to be submitted according to the instructions that will appear in the conference website. Only those abstracts submitted via the official submission website will be considered. There is no cost for submitting an abstract.

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

For additional information please contact the local organizers Jorge E. Gonzalez, Prathap Ramamurthy, and Dev Niyogi via the conference email:
icuc10@ccny.cuny.edu.

INTERNATIONAL ASSOCIATION FOR URBAN CLIMATE

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Newsletter Contributions

The next edition of ***Urban Climate News*** will appear in late September. Contributions for the upcoming issue are welcome, and should be submitted by August 31, 2017.

Editor: David Pearlmutter (davidp@bgu.ac.il)
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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.