

From the IAUC President

Welcome to our last issue of 2017.

As 2017 comes to a close, the **ICUC-10** abstract deadline has been [extended until January 2, 2018](#) to accommodate those who have yet to complete their submissions, recognizing that many will be busy with the end of term and the holiday season. At last report, 550 abstract submissions had been submitted, similar to that at the same point in advance of ICUC-9 in Toulouse. **Jorge Gonzales** and his team have been successful in obtaining new conference sponsorships and are in the process of confirming plenary speakers. The organizers are also working to support some forms of remote participation for those who may be affected by the US travel ban. A reminder that abstract submission is free. We encourage everyone interested in participating in any form to submit an abstract. The organizers will be working to identify those who may need travel or other support in the New Year as abstract assessment gets underway. And on the more general topic of travel for conference participation, [Parish \(2017\)](#) has provided a recent analysis on CO₂ emissions due to air travel arising from the 2012 AGU fall meeting. While ICUC and AGU meetings differ in many respects, the analysis and context are relevant and should be part of our thinking about future ICUCs.

A new initiative, led by **Leena Jarvi**, **Helen Ward** and **Simone Kotthaus**, is taking shape to raise the profile of women in the IAUC. The overall goal is to raise awareness of female potential candidates for keynote speeches, invited presentations, PhD defences, etc. by establishing a database of women members. At this stage the organizers are looking for existing suitable databases that IAUC members could be part of, for example databases that more broadly support women in Geosciences. So a question for IAUC members is "What websites/communities do people know of or use that could be used to support this initiative?" If you have suggestions please let us know. As a part of this initiative, work is also underway with ICUC-10 organizers to host a networking event supporting women in IAUC at ICUC-10.

Inside the Winter issue...

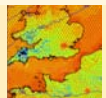
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One other IAUC update; the Awards Committee has recommended that no Luke Howard Award be made this year. We will be initiating the call for nominations early in 2018 for the next award with the intent of completing the process in time for award presentation at ICUC-10. Anyone can initiate a nomination and we are actively seeking additional nominations. See our awards page <http://www.urban-climate.org/awards/> and links to the awards policy for further details. Thanks to **Nigel Tapper**, Chair of the Awards Committee for overseeing the process.

On behalf of the Urban Climate News team and the Board of the IAUC, best wishes to all for 2018.

– 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: Urban Transportation
Entrants (2016): • Addis Ababa (Ethiopia)
 • Mexico City (Mexico)
 • Houston (USA)
Winning City: Addis Ababa
Light Rail Transit (LRT) Project
<http://www.urbanrail.net/af/addis-ababa/addis-ababa.htm>



Traffic jams in Mexico City are a common occurrence

Within the next four decades the global population is projected to increase by 2.3 billion; within the same period it is expected that urban areas will gain 2.6 billion, by absorbing projected growth and continuing to draw from the existing non-urban population. As our community knows, the fastest growing cities will be in Asia and Africa.

The pace of the growth in city-dwellers in these regions creates a huge challenge for city planners, demanding an acceleration in the urban planning process and delivery of large-scale housing and critical infrastructure projects that include energy and water supply, waste removal facilities and of course, transportation. In an ideal situation, urban growth is anticipatory and well managed; in reality, it is often reactionary and in response to specific pressing issues, rather than accounting for future demands. Most of us are familiar with images of extreme congestion, when the urban transportation network is being utilised well beyond its capacity: such examples don't arise over night, but rather due to years of under-investment and a failure to respond to rapid population growth. The winning city for the C40 award in Transportation represented that rare mix of anticipatory, reactionary and visionary urban planning needed to cope with rapid urban growth.

Addis Ababa is the capital of Ethiopia. Population statistics over the past decade have shown the urban population has a net growth of about 400 people per day. Presently, the city is home to over 3.5 million inhabitants, which is about 25% of the total population of Ethiopia. A major symptom of this growth has been growing levels of pollution arising due to increasing levels of traffic on city streets. In fact, a study in 2012 which looked at the whole area of transport in Addis Ababa revealed traffic emissions are the

primary source of all air pollutants in the city and the sector as a whole accounted for nearly 50% of GHG emissions for the entire city. The study cited the aged fleet of cars, buses and minivans as the main problem with respect to air quality. Beyond emissions, however, the study also cited a large number of pedestrians becoming involved in road traffic collisions due "unsafe, hazardous and chaotic" behaviour of private vehicles and the growing problem of congestion. In response to this, and planning for future population growth, city officials commissioned the *Addis Ababa Light Rail Transit Project* or LRT for short.

LRT planning was by no means fast-tracked – it involved rigorous ground based and airborne surveys of the proposed route to be undertaken in three phases up to 2030, including LiDAR mapping of the city along the entire route and building in climate adaptation measures to protect the rail-line from flooding and landslides. Just 3 years later (2015), the LRT opened its first phase: an impressive 34 km running through the busiest parts of the city. C40 noted that this has removed an estimated 1 million private cars already. LRT has doubled the average transport speed across the entire city, improved air quality and is estimated to save 1.8 million tCO₂e by 2030 when the full project will be realised. By completion of its final phase, LRT will span almost 200 km and yield significant social, economic and environmental co-benefits through its provision of low-carbon, reliable and equitably accessible transport, all but removing the need for private vehicles across the city. So that takes care of estimating Q_F from vehicular emissions at least!



LRT has removed over 1 million private cars



Congestion in Addis Ababa

Category: Sustainable Communities

Entrants (2016): • Auckland, New Zealand
• Cape Town, South Africa
• Curitiba, Brazil

Winning City: Curitiba
Curitiba's Urban Agriculture Project
<http://www.curitiba.pr.gov.br/idioma/ingles>



Curitiba and high density development

A sustainable community is one that is economically, environmentally, and socially healthy; through this, it is resilient. But more than this, a significant marker of a sustainable community is that it responds to challenges through integrated solutions rather than through fragmented approaches, and strives to meet shared goals rather than achieving the goals of some at the expense of the others. It can be a difficult concept to realise, and fraught with the kinds of challenges our urban climate community is familiar with. For example, achieving indoor human thermal comfort without impacting negatively on outdoors, or containing the horizontal expansion of cities through the promotion of higher density dwellings, while at the same time ensuring the urban population have sufficient living space to thrive. Looking at the wider issue of sustainable development, we encounter a fundamental challenge of pursuing a shared goal: how do we allow urban development to continue while at the same time significantly curbing GHG emissions?

ban population of over 1.8 million, Curitiba certainly boasts a diversity of ideals and priorities. Despite this, *The Urban Agriculture Project* embodies the ideals of the award and in fact the project mutually satisfied a number of shared goals.

The list includes reducing the UHI, ensuring food security, improving social cohesion, reducing illegal dumping of waste on urban voids, improving water retention, improving carbon sequestration, reducing food transport emissions and raising environmental awareness, to name only a few.

At its core, it is a community-led project which rehabilitates degraded land and utilises this (and other vacant urban spaces in both private and public ownership) to produce food. Through local organic food production, there is an associated reduction in GHG emissions arising from the transport of food, and the increased amount of vegetation comes with all the co-benefits we are aware of, including water retention, carbon sequestration, reducing the amount of energy channelled into sensible heating and so forth. While it is community led, the project is coordinated across the entire city, and has reclaimed 67 million m² of land and generated more than 681,000 kg of food!

The program also fosters social inclusion by providing a therapeutic group activity for all participants, including children, the elderly and those afflicted by drug addiction and mental health issues and runs targeted educational programs to promote environmental awareness. Such cohesion is an essential component of climate change preparedness, and ultimately increases the climate resilience of the entire urban community, young and old.



Beneficiaries of the project

The C40 award in Sustainable Communities recognises these challenges, and is awarded to cities which promote ambitious district-scale low-carbon projects and at the same time promote sustainable communities.

While many in the urban climate community have cited cities as the ideal place to tackle global climate change, given their relative autonomy, when you dig deeper, cities have their own layer of bureaucratic complexities; particularly when space (and its ownership) is at a premium and the concentration of people means one has a number of differing ideals and viewpoints to contend with. Curitiba, the winning city for the C40 award in Sustainable Communities, was recognised for tackling these challenges head on. With an ur-



Promoting social cohesion through shared activities

Chicago Climate Charter Signed by Dozens of North American Mayors

Mayors across North America taking action amidst an absence of leadership and responsibility in Washington

December 2017 — More than 50 mayors from cities and townships participated in the North American Climate Summit in Chicago on Dec. 4-6, whereat they signed the Chicago Climate Charter, an official agreement to reduce greenhouse gas emissions in each of their respective cities. They plan to meet goals comparable to those of the Paris climate accord, the American commitment to which the president vowed to renege.

Former President Barack Obama, who signed the Paris Agreement in 2015 on behalf of the U.S., voiced his support of the mayors' actions during a speech at the summit. In it, he noted that rising sea levels, worsening storms and droughts, and steadily climbing global temperatures present irrefutable evidence that climate is changing in our time, and that it's our fault.

"Miami already floods on sunny days," Obama said, according to reporting from NPR. "Western cities across North [America] are dealing with longer and harsher wildfire seasons. A conveyor belt of some of the strongest hurricanes on record this summer smashed into Houston and Florida and Puerto Rico, and more than two months later, they are still struggling to recover."

He continued; "Obviously, we're in an unusual time when the United States is now the only nation on Earth that does not belong to the Paris Agreement. And that's a difficult position to defend. But the Paris Agreement was never going to solve the climate crisis on its own," Obama said. "It was going to be up to all of us."



Without a serious effort to curb climate change, the oceans will swallow whole cities. Source: futurism.com



Flooded City Dock in Annapolis, Md. Source: <https://futurism.com/mayors-sign-chicago-climate-charter/>

Locally-Grown Paris Agreement

To Obama, and leaders nationwide, the current administration's failure to provide American leadership in combating global climate change has left the work in the hands of local leaders across the nation. The recent summit is an example of how such leaders can band together to make a positive impact on the environment and, ultimately, the future of humanity.

"The North American Climate Summit sends a timely message to leaders around the world that cities are taking strong, swift and measurable action to reduce their greenhouse gas emissions, ensure their communities are more resilient and transition their local economies to benefit from a low-carbon world," said Global Covenant of Mayors Vice-Chair Christiana Figueres, according to a [press release](#). "Cities and local governments have a critical role to play in stepping up ambition on climate change, and it is very encouraging to see so many coming to the table."

Mayors from cities in Mexico and Canada joined their American counterparts in taking real steps to reduce carbon emissions.

Leaders of the summit argue that mayors who commit to the Chicago Climate Charter are in fact signing a first-of-its-kind implementation of the Paris climate agreement, committing their cities to reduce greenhouse gas emissions from the urban ground that first produced them. The Chicago Climate Charter outlines concrete plans for meeting the carbon emission reduction targets by the year 2025.

"This Charter is a great example of how cities are working together and encouraging one another to aim higher, and it will add momentum to America's progress fighting climate change," America's Pledge Co-Chair Michael R. Bloomberg said, according to the press release. Source: <https://futurism.com/mayors-sign-chicago-climate-charter/>

Builders said their homes were out of a flood zone. Then Harvey came.

December 2017 — Leslie Martinez heard the floodwaters before she saw them. They rushed across the lawn, seeped around the doors and into the house. It was 2:15 a.m. on Aug. 28, three days after Hurricane Harvey made landfall. Her young daughter was asleep in her arms. Ms. Martinez's first reaction was to spread towels around the floor.

After all, Ms. Martinez recalled, the home builder had assured her that "flooding was not even a possibility" when she and her husband purchased the house in this suburban enclave north of Houston in 2011. They would never have bought here otherwise. Flood insurance, of course, was neither required nor needed.

Now, with the rains outside lashing and the water inside rising, the family and their terrified pet, a one-eyed goldendoodle named Coco, took refuge on the second floor. Later that day, rescue boats came and ferried them to safety.

The flooding forced Ms. Martinez and her husband, John Ahearn, to borrow money from their parents and accept a donation from their daughter's school. It left them feeling furious and betrayed. "I'm scared that it's going to continue happening," Ms. Martinez said, even as she wondered how they had become the victims of something they had been told had a vanishingly small chance of coming to pass in such a short time since the purchase.

What they did not know was that their home, and those of many of their flooded-out neighbors in this new section of The Woodlands, had been built on land that not long ago lay squarely, and sometimes soggy, in a flood plain.

A New York Times examination found that in the years leading up to Hurricane Harvey, with a surging local economy fueling demand for new upscale housing, the developers of The Woodlands had used a wrinkle in the federal flood-mapping system — along with many dump trucks' worth of dirt — to lift dozens of lots out of the area officially deemed prone to flooding. What they had done, in effect, was create gerrymandered maps of risk.

In Ms. Martinez's case, documents show, the land was raised less than 10 inches above the level that, under federal flood-insurance rules, would have required the family to be notified of their risk and purchase insurance. Other lots in their area were raised as little as 1.2 inches above that height.

No one has suggested that the developers broke any laws, and the company that owns The Woodlands says it followed all applicable regulations and standards. But the experiences of the family of Ms. Martinez and their



The view outside Ms. Martinez's second-floor window in the aftermath of Hurricane Harvey. Source: [nytimes.com](https://www.nytimes.com)

neighbors show that even when the mapping rules are followed to the letter, the results can be disastrous.

The adjustment process began as a way to correct the wild inaccuracies in the maps that form the basis of the federal flood-insurance program, which was created in the 1960s to protect homeowners from catastrophic loss. Increasingly, though, the changes have also become a way for developers to build on low-lying land.

Across the country, documents show, the Federal Emergency Management Agency, which runs the insurance program, has granted more than 150,000 map changes in the last five years. In some cases, lots were raised, and in others, levees, drainage systems, water-detention ponds and other methods changed the calculated flood risk for a swath of land.

Many of these changes were unquestionably appropriate. But in the Houston area, a Times analysis of FEMA documents shows, at least 6,000 properties in redesignated zones were damaged during the flooding caused by Harvey.

"This is all about engineers doing things for developers rather than for the public," said James B. Blackburn, co-director of the Severe Storm Prediction, Education and Evacuation from Disasters Center at Rice University in Houston. Mr. Blackburn, who was involved in early designs of The Woodlands, added, "It would be nice to know that you were only two inches above the flood plain. You know, that's not a lot of margin for error on these maps. Yet all the federal protection for flood insurance gets removed."

What happened in The Woodlands underscored one of the great lessons of Harvey's assault on Houston: the profound vulnerability of a metropolis with an ethos of un-



100-year flood plain
 Outside of flood plain
 Approximate extent of Harvey flooding

Developers hauled thousands of truckloads of dirt to raise home lots above the flood plain (left). But Hurricane Harvey inundated many of the recently built homes in this area (right). Source: nytimes.com

trammled development built, essentially, on a swamp. To Ms. Martinez and her neighbors, the cruel twist was that it could happen here — in a community founded in 1974 as a kind of anti-suburbia by an oil and gas billionaire named George P. Mitchell. If The Woodlands was a community apart, rich with woods, lakes, trails and streams, Mr. Mitchell was its benevolent dictator, whose vision of building quality and environmental balance fostered a reputation of a development where the flood risk was extremely low.

Mr. Mitchell sold his company's stake in The Woodlands Development Company in 1997, and the community has been steered by a succession of publicly traded companies — most recently, the Howard Hughes Corporation, which bought a major stake in 2010 and acquired the rest the next year.

Don Hickey, a 37-year resident of The Woodlands who was an early employee of Mr. Mitchell, said people paid more to live here in part because they felt they would be safe. Mr. Hickey, who works in real estate finance and is collaborating with fellow homeowners to get their flooding problems fixed, summarized the situation in caustic terms, saying, "The developer had an economic benefit to more aggressively develop land around the flood plain or spend less money on flood control."

The company says there has been no slippage of quality through the transition of ownership.

"Since development began at The Woodlands more than four decades ago, it has strived to be a model master-planned community. While ownership has changed, what has never changed — nor will ever change — is our strict adherence to standards and our commitment to our communities," said Grant Herlitz, president of the Howard Hughes Corporation.

Hurricane Harvey, the company argues, was an exceptional flooding event, and all map revisions followed federal and local guidelines. "To the extent that standards are re-evaluated, we will do as we have always done and act in accordance with any new regulations," Mr. Herlitz said.

Boundaries of Risk

The National Flood Insurance Program and the flood maps used to establish the need for insurance have been a constant source of controversy. Critics of the program argue that it often ends up repeatedly paying for damaged properties instead of pressing for mitigation of flood risks and relocation, and thus ends up encouraging people to build — and rebuild — in risky places. The risk is defined by law, not nature: FEMA and the flood insurance program look to what is known as 100-year flood elevation to determine who needs to buy insurance. Anything lower than that is considered to be in the flood plain. Above that level, supposedly, is safety.

But how safe? The 100-year flood level does not mean a flood will happen only once every 100 years. Instead, it refers to a 1 percent chance of flooding in any given year. (A 500-year flood, which reaches somewhat higher elevation, is one with a .2 percent chance of occurring in a year.) That 1 percent chance actually translates into a one-in-four chance of a flood occurring at least once during the life of a 30-year mortgage. And in Houston, as in many parts of the country, 100-year floods are distressingly common. The Houston area saw three such events in the past three years. Climate change threatens to make them even more likely.

To Mr. Blackburn, the 100-year line is too arbitrary for comfort. What's more, the flood maps have long been considered highly inaccurate.

This led to a lot of unhappiness among homeowners forced to pay perhaps \$5,000 annually for insurance that would cost less than a tenth of that outside the official flood plain.

“People started to come in and argue and said, ‘You showed me in a flood plain and I’m 40 feet above that level.’ Because FEMA’s topography was so inaccurate,” said Larry A. Larson, director emeritus of the Association of State Floodplain Managers in Madison, Wis.

By the 1980s, he said, the agency, too overwhelmed and underfinanced to make all the corrections itself, instituted new procedures for accepting revised elevation data from engineers hired by aggrieved citizens.

Developers have taken advantage of the new system as well, FEMA documents show, with a range of techniques from hiring surveyors to correct elevations to building structures like levees and drainage channels. In one of the most common methods, developers truck in tons of soil — known as “fill” in the building trade — and dump it over wide areas to raise the elevation above the flood plain. Mr. Larson called changes that lifted the ground only slightly above the flood plain “a bad idea” because such areas generally remain prone to flooding.

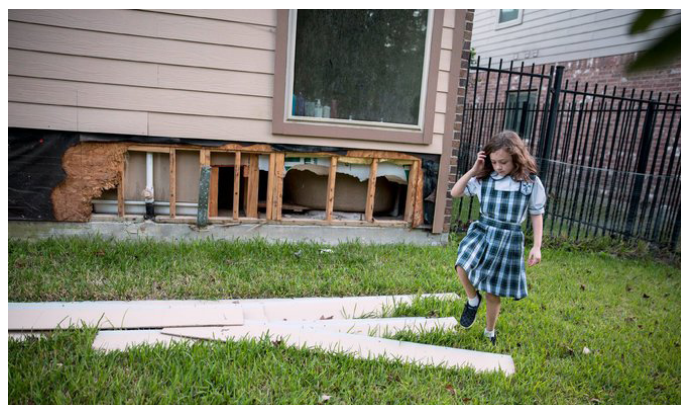
“Once a flood plain, always a flood plain,” he said. “It’s still got risk.”

His observation was borne out in striking fashion in the neighborhoods covered by the two map revisions examined by The Times: Eighty of the 81 homes within those areas near Spring Creek — which flows through The Woodlands — sustained some degree of flooding, according to FEMA statistics.

Harris County, home to large parts of suburban Houston, including the newer sections of The Woodlands, is one of a handful of districts around the nation that FEMA has granted a sort of shared authority in approving map revisions. Although the conditions of this authority are complex, and vary from district to district, others have used it to enforce standards that are more stringent — for example, generally requiring higher elevations for any change and pushing developments further from creeks than FEMA does.

For its part, Harris County has stuck with FEMA’s elevation standards. “We don’t want to touch the FEMA process; we want to keep it intact,” said Ataul Hannan, planning division director for the Harris County Flood Control District.

What the county has done is put a great deal of effort, and expense, into creating a special software model for more accurately calculating flooding risks and the wider effects of development in the relatively flat terrain of the Houston area, Mr. Hannan said. Comparing Harris County’s regulations to those in other parts of the country is unfair, he added, because the topographies are so different.



Alex, 7, walking in her family’s backyard near siding that was damaged during the flood. Source: nytimes.com

In the business of flood-map revision, the pressure usually runs one way. There is seldom much local interest in having a neighborhood declared flood prone, said Sarah Pralle, an associate professor of political science at Syracuse University who studies the politics of flood insurance and has written about lobbying efforts by New York and New Orleans to alter the maps.

“The shrinkage of the flood maps,” she said, “is always treated in a very positive way.”

Shifting Terrain

As early as 2006, The Woodlands filed a plan for a new subdivision on thousands of acres containing “wooded areas and a few rural home sites,” according to documents obtained from Harris County. But it was not until the years leading up to 2011, when the Hughes Corporation put together the final pieces of its purchase of The Woodlands, that the housing market caught up with the plan. Houston shook off the wreckage of the subprime mortgage crisis and encountered a very different problem: a shortage of housing on the high end of the market.

Touching off the surge in demand was an announcement by Exxon that it was opening a new corporate campus in nearby Spring. Exxon was far from alone, as a growing list of companies relocated to the area. So did tens of thousands of workers, drawn by the boom in fracking technologies that none other than Mr. Mitchell and colleagues had coaxed, tweaked and perfected over nearly 20 years.

That influx would have all but saturated the existing home market, said Bill Gilmer, director of the Institute for Regional Forecasting at the University of Houston. It drove a spike in land prices, allowing developers to consider new construction on relatively low-cost lots that previously would have been too costly to improve. “This would just give you the opportunity to make those extensive improvements and still come out ahead,” Mr. Gilmer said.

FEMA maps of The Woodlands showed a tantalizing stretch of undeveloped land hard by a waterway called

Spring Creek — including acreage in the 2006 plan. Building right along the creek would have been out of the question, but farther south, portions of the land were slightly above the 100-year flood plain, according to the maps. Those who knew the land and its history saw warning signs. Nick Rife, whose family owned land in the area, said he used to hunt there “when it wasn’t flooded.”

By bringing in thousands of dump truck loads of dirt, it would be possible to expand the acreage above the flood plain, making the whole area suitable for construction. That is exactly what The Woodlands decided to do, documents show.

The former edges of the flood plain run through what are now the lots of Ms. Martinez and Mr. Hickey, the long-time Woodlands resident who once worked for Mr. Mitchell and had built a new home in the neighborhood. On the strip of land containing Wood Drake Place — Ms. Martinez’s street — 60,907 cubic yards of dirt were laid down. FEMA approved a map change for that area on Feb. 8, 2011, documents show. The large extrusion of development around Lake Reverie Place — Mr. Hickey’s street — and the nearby Sundown Ridge Place got 19,890 cubic yards of dirt. On June 13, 2013, FEMA approved a map change for what would become lots for the 81 homes in those areas.

The result: neighborhoods that seemed safe from flooding. When Esteban and Paola Seañez moved into their home next to Spring Creek in 2015, their mortgage company assured them that the plot was high and dry. When the couple asked about flood insurance, “They said, ‘You don’t even have to purchase it,’” Ms. Seañez recalled.

Last year, after water came within several feet of their door, Mr. Hickey’s neighbors James and Gayle Soeder inquired about flood insurance. Initially, the agent warned that the policy would be very expensive; the house was in a flood plain, she said. Mr. Soeder, who knew he had bought a home at the 500-year elevation, asked her to check again. “We see that the flood plain was revised recently,” the agent said. So, for a bargain rate of \$450 per year, the Soeders became one of the families in the neighborhood to be covered by insurance when Harvey struck.

A number of residents asked whether managers of The Woodlands since Mr. Mitchell had been as careful as its predecessors in designing the newer developments, and pointed to what they called more aggressive policies since the Howard Hughes Corporation — a brand revived in 2010 by the activist investor Bill Ackman — took over.

Mr. Hickey dug into damage statistics and found that his recently constructed neighborhood flooded at far higher rates than others in The Woodlands. In older parts of the community, his research revealed, about 215 out of 33,000 homes flooded during Harvey, or less than 1 percent — a far smaller percentage than many other communities in the greater Houston area. Yet among

homes built in more recent years in Harris County, 331 out of 4,993 flooded, or more than 6 percent.

In the newest areas of that Harris County expansion, including those where the Soeder, the Hickey and the Seañez families live, 331 out of 1,450 homes were affected — a whopping 23 percent. Mr. Hickey questioned whether adequate measures had been taken in the fill project to provide water storage and drainage in big storms. Marc Crudgington, who bought his home the year after Ms. Martinez and her husband did, voiced similar concerns.

“They’ve filled in lakes that have been around forever just so they can build on them, and clear-cut trees like nobody’s business,” he said. “Our name for it is not The Woodlands, it’s Concrete Land.”

The company stated that “the senior development team is ‘essentially the same team’ that has worked on The Woodlands for 25 years.”

Tim Welbes, co-president of The Woodlands Development Company, said the company had complied with FEMA standards for its homes, but that the neighborhood had been overwhelmed by the storm’s waters. “We met the standard,” he said. “This event exceeded the standard.”

Still, at a recent meeting of The Woodlands Storm Drainage Task Force, residents expressed anger at local officials over the damage to homes from Hurricane Harvey — and, for many of them, from earlier floods. This task force was actually formed last year in response to previous flooding, and little had been done to improve the situation before Harvey. Steve English, 71, said the value of his house has dropped to \$400,000 from \$800,000 after the two floods. Hurricane Harvey brought 30 inches of water into his home.

“Do we all have to get to where our house is down to \$50 and we have to walk out of here naked before you do anything?” he said.

Any fixes could take years, and are quite likely to require coordinating efforts among communities and the state of Texas. Until then, homeowners stew, fret and wait for the next big storm. Raul Giorgi, a real estate agent in The Woodlands for 35 years, owns a home near the Soeders that also was damaged.

He made the same decision to buy there that his customers make — and, like his clients, his ability to dig through years of regulatory decisions and paperwork is limited. They look to real estate agents like him, he said, for information about risks, and he looks to the developers. “Who am I? I’m not an engineer,” he said. “All I can do is trust the experts.”

Now, he says, “I personally believe, in hindsight, this should not have been developed.” *Source:* <https://www.nytimes.com/2017/12/02/us/houston-flood-zone-hurricane-harvey.html? r=0>

The three-degree world: the cities that will be drowned by global warming

The UN is warning that we are now on course for 3°C of global warming. This will ultimately redraw the map of the world

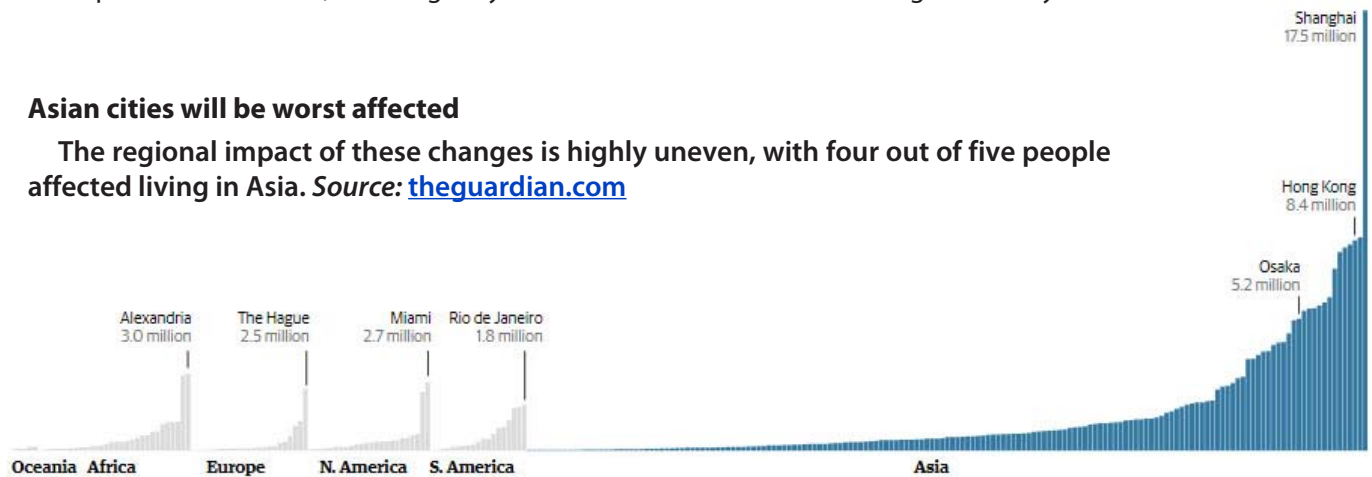
December 2017 — When UN climate negotiators meet for summit talks this month, there will be a new figure on the table: 3°C.

Until now, global efforts such as the Paris climate agreement have tried to limit global warming to 2°C above pre-industrial levels. However, with latest projections pointing to an increase of 3.2°C by 2100, these goals seem to be slipping out of reach. “[We] still find ourselves in a situation where we are not doing nearly enough to save hundreds of millions of people from a miserable future,” said Erik Solheim, the UN environment chief, ahead of the upcoming Bonn conference.

One of the biggest resulting threats to cities around the world is sea-level rise, caused by the expansion of water at higher temperatures and melting ice sheets on the north and south poles. Scientists at the non-profit organisation Climate Central estimate that 275 million people worldwide live in areas that will eventually be flooded at 3°C of global warming. Although sea levels will not rise instantaneously, the calculated increases will be “locked in” at a temperature rise of 3°C, meaning they will be irreversible even if warming eventually slows down.

Asian cities will be worst affected

The regional impact of these changes is highly uneven, with four out of five people affected living in Asia. *Source: theguardian.com*



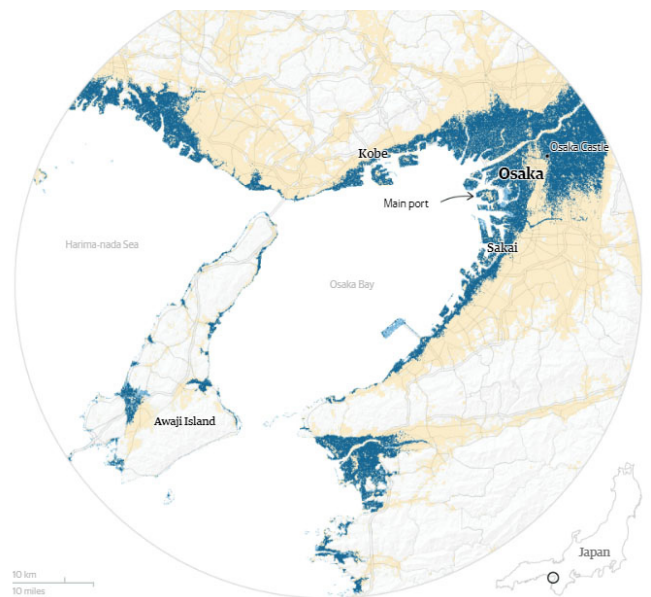
Osaka, Japan: 5.2 million people affected

At the end of a month in which it has been battered by unseasonably late typhoons and relentless rain, Japan is already confronting the threat posed by climate change-induced flooding.

Image modelling shows that swaths of Osaka – the commercial heart of a region whose GDP is almost as big as that of the Netherlands – would disappear beneath the water in a 3C world, threatening the local economy and almost a third of the wider region’s 19 million residents.

As a result of global sea-level rise, storm surges and other factors, economists project that coastal flooding could put almost \$1tn of Osaka’s assets at risk by the 2070s, according to the Union of Concerned Scientists.

“The costs of protecting cities from rising sea levels and storms are also likely to rise - as are the costs of repairing storm damage,” it said. “Decisions we make today could have a profound impact on the security and culture of the people of this ancient city.”



Much of the urban area surrounding Osaka (pink) is populated terrain that could be reshaped by sea-level rise (blue). *Source: theguardian.com*

Like much of Japan, Osaka already has a network of seawalls and other coastal defences in place to combat tsunami – although their effectiveness was disputed in the aftermath of the 2011 triple disaster.

Osaka city authorities are investing in other infrastructure to mitigate the effects of flooding, but public education is also vital, according to Toshikazu Nakaaki of the Osaka municipal government’s environment bureau.

“In the past our response was focused on reducing the causes of global warming, but given that climate change is inevitable, according to the Intergovernmental Panel on Climate Change (IPCC), we are now discussing how to respond to the natural disasters that will follow,” Nakaaki said.

“We anticipate that Osaka will be affected by natural disasters caused by climate change, but we have yet to establish exactly what might happen or how much financial damage they would cause.

“It’s not that we expect sea levels to rise at some point in the future – they are already rising.”

Keiko Kanai has long been aware that her home city is susceptible to natural disasters. “I’d heard that historically, tsunamis caused by earthquakes put many parts of Osaka underwater, and I knew that some parts of the world were at risk from rising sea levels,” said Kanai, who teaches at a local university.

“But I didn’t put two and two together. Until now I haven’t given much thought to the idea that Osaka too could be engulfed by rising sea levels.”

Kaori Akazawa, a nursing care consultant, said flooding was a consideration when she was deciding where in Osaka to live. “When I moved here I talked to my colleagues about the risks,” she said. “That’s why I’ve always rented apartments on the fourth storey or higher.

“It’s worrying, but I’ve never considered moving.”

—Justin McCurry in Tokyo

Alexandria, Egypt: 3 million people affected

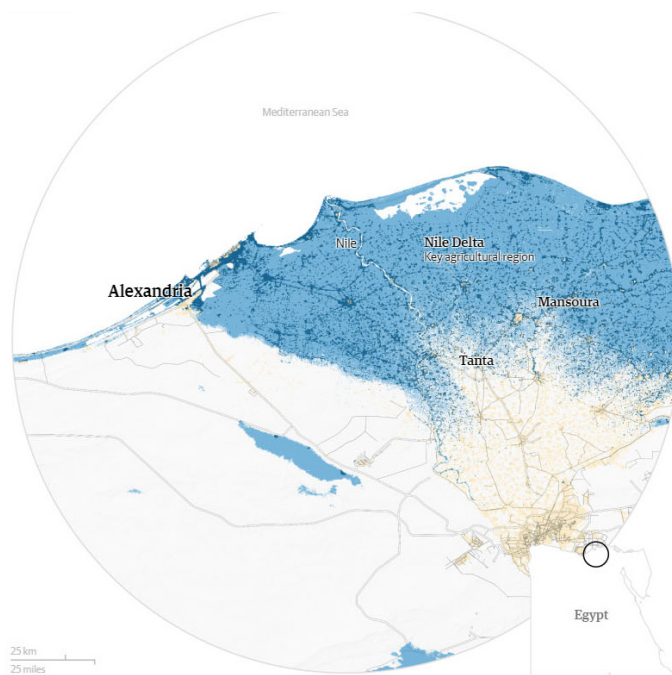
On the Alexandria Corniche, waves slowly lap at a shoreline dotted with plastic chairs and umbrellas from the beachside cafes. Students perch on the steps of the imposing Alexandria library. But the same coastline that draws locals to its scenic vistas is threatening to slowly engulf the historic city as sea levels rise due to global warming. The IPCC reported that Alexandria’s beaches would be submerged even with a 0.5-metre sea-level rise, while 8 million people would be displaced by flooding in Alexandria and the Nile Delta if no protective measures are taken. A 3C world threatens far greater damage than that.

Yet for many residents, there is little public information to connect the increasingly chaotic weather and floods with climate change. “The vast majority of Alexandrians don’t have access to knowledge, and that’s what worries me. I don’t expect the government to raise awareness of this problem until it’s already happening,” said 22-year-old student Kareem Mohammed.

“Everyone thinks we should act on this problem 50 or 80 years from now,” agreed his friend, Hazem Hassan, a student in marine biology at the nearby Alexandria University.

Officials maintain that protective measures are being taken, but with little fanfare. “Egypt spends 700m EGP [£30m] annually to protect the north coast,” said Dr Magdy Allam, head of the Arab Environmental Experts Union, who was previously part of the Egyptian environment ministry.

Allam cited the Mohammed Ali sea wall built in 1830 as a key protection, as well as the concrete blocks lining the shoreline designed to “detour flood water away from



Much of the urban area surrounding Alexandria (pink) is populated terrain that could be reshaped by sea-level rise (blue). Source: theguardian.com

residential neighbourhoods”. But critics say that this is far from enough given the scale of the problem.

“There are studies indicating that our city is one of many coastal human settlements around the world which will be partially submerged by 2070 if nothing is done,” said Ahmed Hassan, of the Save Alexandria Initiative, a group that works to raise awareness of the effects of climate change on the city.

—Ruth Michaelson in Alexandria

Rio de Janeiro, Brazil: 1.8 million people affected

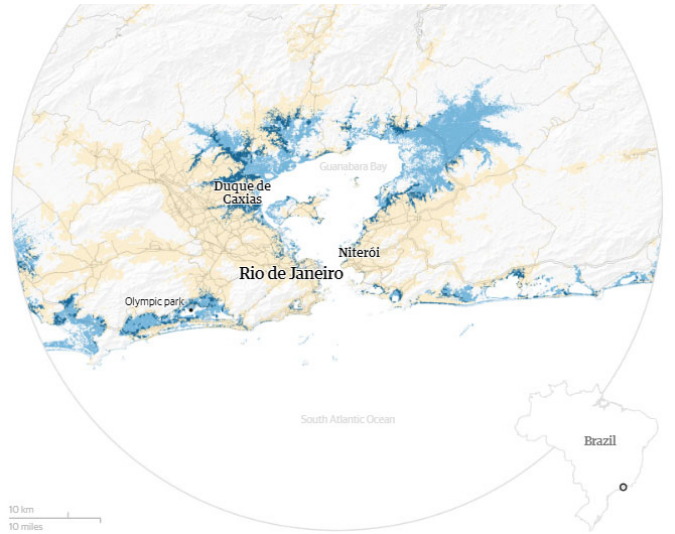
Residents of Brazil's postcard city have plenty of reasons to fear global warming – even if they don't quite know it. According to Climate Central, a temperature rise of 3C would cause flooding of not just Rio's famous beaches such as Copacabana and its waterfront domestic airport, but also inland areas of the Barra de Tijuca neighbourhood, where last year's Olympic Games were held.

Barra is built around a network of heavily polluted lagoons that empty into the sea. The prospect of it being underwater alarmed resident Sueli Gonçalves, 46, who runs pensioners' health projects, as she and her 23-year-old son Yuri Sanchez carried their shopping past the Olympic Park. "My God. Oh Jesus," she said, with a nervous laugh. "I will leave here. I will go to the United States. To Canada."

The family knew about global warming but were unaware of the potential scale of the impact on their upscale neighbourhood of smart condominiums and a shopping mall. "Nobody takes it seriously. People do not think long term," Gonçalves said.

Storm surges recently destroyed hundreds of metres of beachfront pavement overlooking the Macumba beach, a popular surfing spot on Rio's western fringes. Last year, heavy waves in another storm surge felled an elevated, clifftop cycle path between Leblon beach and Barra de Tijuca which had not been built to survive such high seas, killing two people.

Last year, Rio's city government and the Federal University of Rio de Janeiro produced a study entitled Strategy for Adapting to Climate Change. "The current challenge consists in deepening knowledge and monitoring of oceanic phenomena and the evolution of the sea bed and coast," a



Much of the urban area surrounding Rio de Janeiro (pink) is populated terrain that could be reshaped by sea-level rise (blue). Source: theguardian.com

spokeswoman for the city's secretariat of the environment said in an email. An "adaption plan" for climate change produced with professors from the federal university suggested strategies to deal with vulnerabilities in areas such as transport, health and housing. But so far little has been done.

Nara Pinto, 38, who lives in the sprawling Rocinha favela and sells snacks on the pavement overlooking Copacabana beach, said the loss of Rio's famous beaches would cost a lot of jobs.

"The beach is a tourist point," she said. "What can be done to stop this?"

—Dom Phillips in Rio de Janeiro

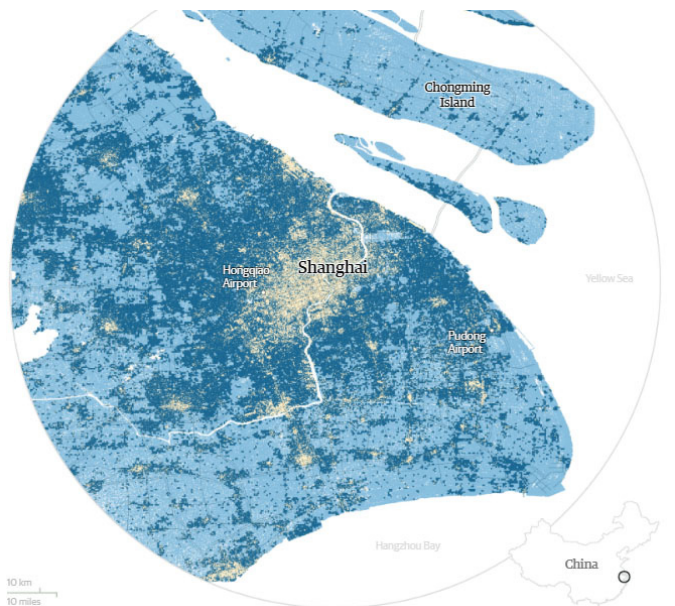
Shanghai, China: 17.5 million people affected

"Shanghai is completely gone – I'd have to move to Tibet!" says resident Wang Liubin, when he is shown projections for the city after 3C of global warming.

When it comes to flooding, the coastal city is one of the world's most vulnerable. Now one of the world's biggest ports, the former fishing village is bordered by the Yangtze river in the north and divided through the middle by the Huangpu river; the municipality involves several islands, two long coastlines, shipping ports, and miles of canals, rivers, and waterways.

In 2012, a report from a team of UK and Dutch scientists declared Shanghai the most vulnerable major city in the world to serious flooding, based on factors such as numbers of people living close to the coastline, time needed to recover from flooding, and measures to prevent floodwater. According to Climate Central projections, 17.5 million people could be displaced by rising waters if global temperatures increase by 3C.

Projections show the vast majority of the city could



Much of the urban area surrounding Shanghai (pink) is populated terrain that could be reshaped by sea-level rise (blue). Source: theguardian.com

eventually be submerged in water, including much of the downtown area, landmarks such as the Lujiazui skyline and the historical Bund, both airports, and the entirety of its outlying Chongming Island.

Since 2012, the government has been making steady inroads to tackle the threat, including building China's largest deepwater drainage system beneath the Suzhou Creek waterway, made up of 15km of pipes to drain rainwater across a 58 sq km area. It has also rolled out a 40bn yuan (£5bn) River Flood Discharge project which will stretch for

120km between Lake Taihu and the Huangpu river to try and mitigate the risk of the upstream lake flooding.

Flood prevention walls are being built along the waterfront – in places so high the river is blocked from view – and 200km more are promised across the city's outlying districts. Flood controls have been put in place along the famous Bund waterfront, where the walkway has been raised to help counter a flood risk, as well as a series of water controls and dams.

—Helen Roxburgh in Shanghai

Miami, US: 2.7 million people affected

Few other cities in the world have as much to lose from rising sea levels as Miami, and the alarm bells sound ever louder with each successive "king tide" that overwhelms coastal defences and sends knee-deep seawater coursing through downtown streets.

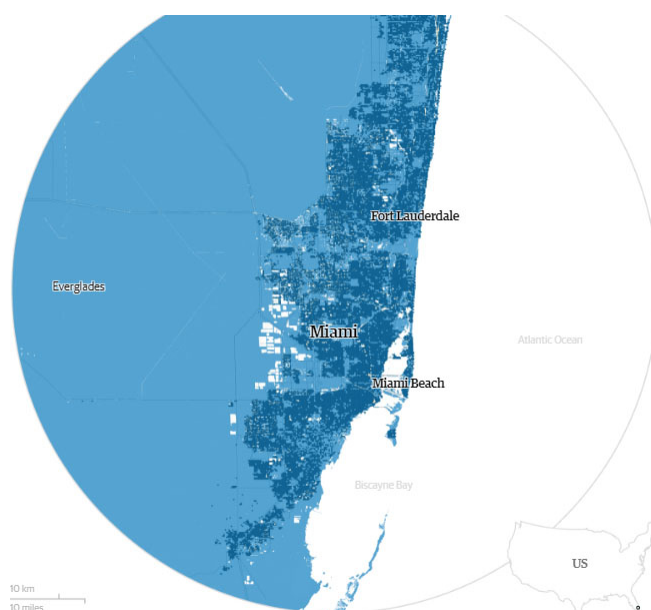
Locals consider this the "new normal" in the biggest city of Florida's largest metropolitan area, which would simply cease to exist with a 3C temperature rise. Even at 2C, forecasts show almost the entire bottom third of Florida – the area south of Lake Okeechobee currently home to more than 7 million people - submerged, with grim projections for the rest of the state in a little more than half a century. In Miami-Dade county alone, almost \$15bn of coastal property is at risk of flooding in just the next 15 years.

A sense of urgency is evident at city hall, where commissioners are asking voters to approve a "Miami Forever" bond in the November ballot that includes \$192m for upgrading pump stations, improving drainage and raising sea walls.

"We have a really precious city that many people love and are willing to invest in right now, but it's going to take some funds to protect it," said Ken Russell, the city commission's vice-chair.

Last year, the city of Miami appointed sea-rise expert Jane Gilbert into the newly created role of chief resilience officer with instructions for a robust stormwater management plan that also looks at storm surge, such as that from Hurricane Irma in September which brought significant flooding to downtown Brickell and neighbouring Coconut Grove.

Proposals include elevating roads and even abandon-



Much of the urban area surrounding Miami (pink) is populated terrain that could be reshaped by sea-level rise (blue). Source: theguardian.com

ing neighbourhoods to the water to protect others.

"We need universal recognition that we're all in this together, to protect this amazing global city that we've become," she said.

Natalia Ortiz, who grew up in Miami, fears the future. "It's very scary," said Ortiz, who works with Cleo, a climate change advocacy group.

"My son is 11 and my daughter is nine, so they're young but I think about their future, will they be able to raise their children in Miami the way I had the luxury of raising mine?"

—Richard Luscombe in Miami

Methodology – Flood maps were created using sea-level rise estimates from Climate Central and digital elevation data. Population estimates refer to urban agglomerations which comprise the built-up area of a city and the suburbs linked with it. Maps include OpenStreetMap data.

Temperature projections are based on University of

Washington emissions modelling and UN warming estimates. Trajectories have been updated to match latest temperatures as recorded by the Met Office Hadley Centre.

Source: <https://www.theguardian.com/cities/ng-inter-active/2017/nov/03/three-degree-world-cities-drowned-global-warming>

Urban Multi-scale Environmental Predictor – An extensive tool for climate services in urban areas



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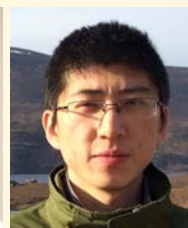
This article draws on the recently published open access paper:

Lindberg F, CSB Grimmond, A Gabey, B Huang, CW Kent, T Sun, NE Theeuwes, L Järvi, H Ward, I Capel-Timms, YY Chang, P Jonsson, N Krave, DW Liu, D

Meyer, KFG Olofson, JG Tan, D Wästberg, L Xue, Z Zhang (2018) Urban multiscale environmental predictor (UMEP) – An integrated tool for city-based climate services. *Environmental Modelling and Software* 99:70–87 (10.1016/j.envsoft.2017.09.020)



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Introduction

Scientists and practitioners from a broad range of disciplines, including architecture (e.g. Ren et al. 2010), climatology (e.g. Eliasson 2000), planning (e.g. Alcoforado et al. 2009), engineering and geography, have long been interested in how weather and climate affects cities and their occupants. Today, the collective knowledge on how urban areas affect the climate and how the urban dwellers are affected by the same climate is remarkable. However, the transfer of this knowledge between urban climatologists and end-users could be improved (Hebbert and Mackillop 2013) and the development and adoption of city based climate services, which require production, translation, transfer, communication, and use of climate knowledge and information, for urban planning, building design and the operation of cities is not straight-forward (Chrysoulakis et al. 2013; Grimmond et al. 2014, Baklanov et al. 2017). Models at scales appropriate for climate services for urban areas are only now being developed and the availability of input data (e.g. surface and atmospheric) can be challenging to access and often in user-unfriendly formats that are inaccessible to many end-users. Communication and interaction between producers and users of climate services has been poor, with outputs often not easily interpretable by non-specialists. These challenges indicate a need for common tools that are more user-friendly, and technically and economically accessible, to improve communication across disciplines, researchers and users, to better identify user needs that need to be addressed, to ensure common assumptions, and to build capacity to ad-

dress urban climate and weather concerns, and transfer research into practice.

To address this need, we introduce UMEP (Urban Multi-scale Environmental Predictor) an integrated tool for urban climatology and climate-sensitive planning applications (Lindberg et al. 2018). The tool can be used for applications related to outdoor thermal comfort, urban energy consumption, climate change mitigation, etc. UMEP consists of a coupled modelling system which combines state-of-the-art 1-D and 2-D models with systems to input data from multiple sources, formats and at different temporal and spatial scales, and to generate output as data, graphs and maps. An important attribute of UMEP is its ability to couple relevant processes that occur at different temporal and spatial scales. Here the basic structure of UMEP is described along with practical applications of the tool to illustrate its potential.

UMEP is being developed as a community, open source tool to enable its use without restriction with respect to cost, license or rights issues. Users can also contribute to the tool to enhance and extend its capabilities. One of its major features is the ability for users to interact with spatial information to determine model parameters, and to edit, map and visualize inputs and results. For this reason, the software is written as a plug-in to QGIS, a cross-platform, free and open source desktop geographic information system (GIS) application (QGIS Development Team, 2017). The long term release of UMEP is directly available through the official QGIS Python Plugin repository (<https://plugins.qgis.org/plugins/UMEP/>).

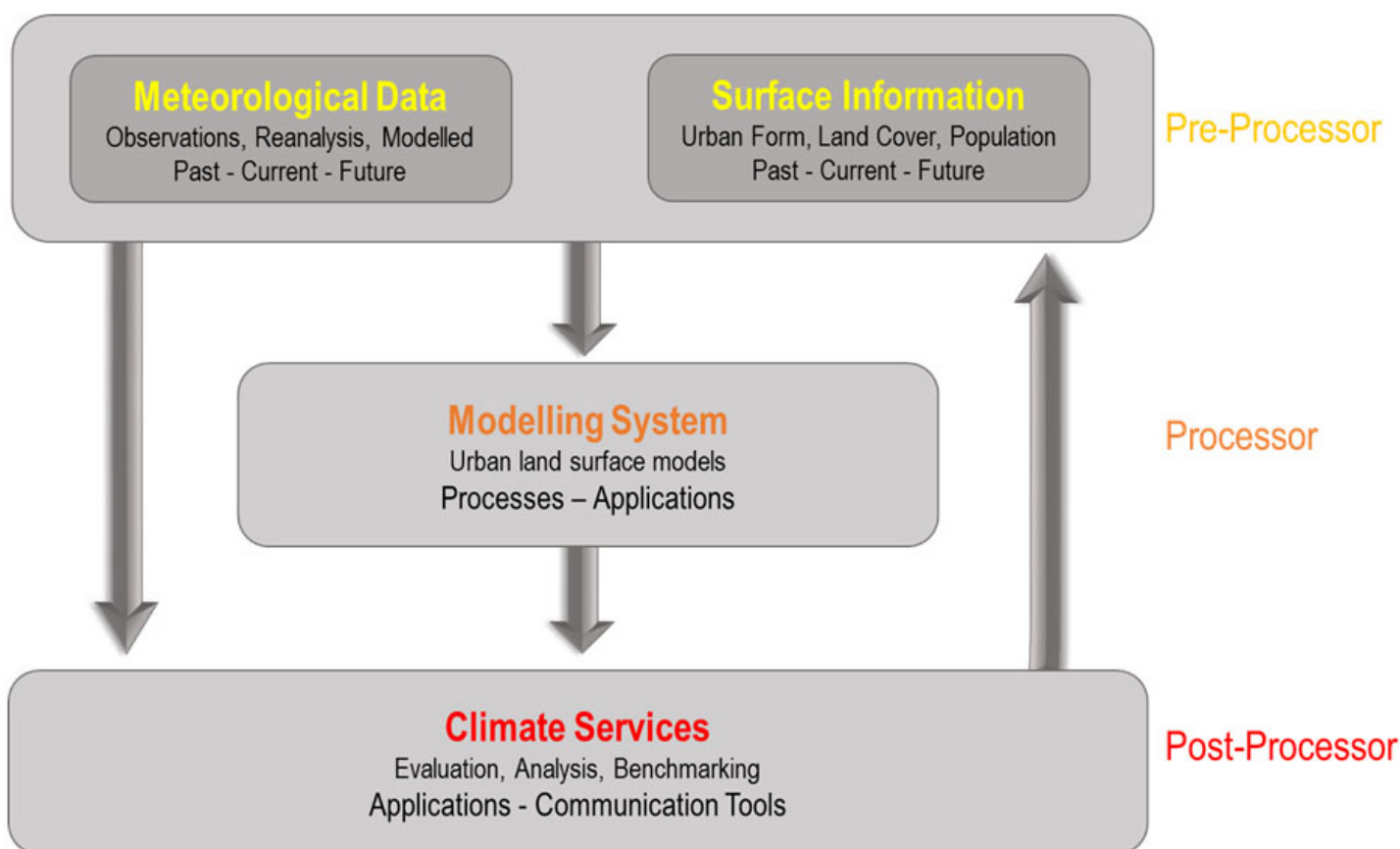


Figure 1. Structure of UMEP (Urban Multi-scale Environmental Predictor). From Lindberg et al. (2018)

UMEP has three main elements (Figure 1): pre-processor (for inputs of meteorological and surface information); processor (modelling system e.g. Urban Land Surface Models, ULSM); and post-processor (tools to analyze the outputs (individual and ensemble, indicators of uncertainty, user applications etc.)). Each tool is described briefly in Table 1, with more complete details presented in the online manual (www.urban-climate.net/umep). UMEP allows users to integrate atmospheric and surface data from multiple sources and compare and visualize results or scenarios for different climate indicators of concern or interest (heat indices, intense precipitation, water/energy demand) at a range of spatial scales consistent with end-users' needs and interests. To aid capacity development a series of tutorials have been developed, accessible from the online manual.

An important part of UMEP is to facilitate the preparation of input data needed for City-Based Climate Services (CBCS). UMEP provides both [guidance](#) and tools that enable the preparation and manipulation of data (Table 1). This is particularly important as most end-users are familiar with some, but not the full spectrum of data needed for applications. For example, planners are knowledgeable about building heights, materials and their spatial

arrangement (i.e. urban surface data) and often have geographic information system (GIS) skills, but they do not necessarily have detailed knowledge of meteorological data. Equally, those knowledgeable in the latter may not be expert in the former. Although remotely sensed data may play a very useful part of providing CBCS, these data may require further processing to be applicable in urban areas. UMEP has been designed to enhance their integration.

UMEP modelling capabilities

UMEP's broad range of capabilities is summarized in Table 1. Components may be used independently or in combination. Users may be interested in the output from tools that are provided in the pre-processor for other modelling applications (e.g. in generating urban surface information or standardized meteorological fields; these may be used by models internal to UMEP or other models external to UMEP), or users may be interested in an application that requires a chain of tools to provide climate indicators for decision making. Many of the individual tools, and their evaluation, have been described in disciplinary focused papers (see Lindberg et al. 2018 for a detailed list of references).

Table 1. Description of UMEP components and scales they are applicable to [C: city; L: local (neighbourhood); M: micro (e.g. street canyon, park)]. Note: micro scale applications are usable across a whole city, but will likely be computer intensive.

Component	Scales	Description
<i>Pre-Processor</i>		
Prepare existing data	C/L/M	Formats meteorological data for input to the models, dealing with missing data
Download data (WATCH)	C/L	Re-analysis data modified for use in an urban context, representative of the local scale
Spatial Data Downloader	C/L/M	Downloads spatial data from public servers
DSM Generator	C/L/M	Creation/manipulation of digital surface models
Tree Generator	C/L/M	Creation/manipulation of 3D vegetation data
LCZ Converter	C/L	Allows morphometric parameters and land cover fractions to be calculated from Local Climate Zone (LCZ) maps.
Sky View Factor	C/L/M	Amount of the hemisphere with restricted view of the sky
Wall Height Aspect	L/M	Height and orientation of buildings and walls
Land cover reclassifier	C/L/M	Geodata can be translated into the land cover classes used by all models
Land cover fraction (point)	L/M	Surface cover fractions are determined for an area or specific directions
Land cover fraction (grid)	C/L	As above, but a grid is used to determine fractions for multiple areas.
Morphometric Calculator (point)	L/M	Morphometric parameters are determined for an area or specific directions can be used.
Morphometric Calculator (grid)	C/L	As above, but a grid is used to determine parameters for multiple areas.
Source area (point)	L/M	As above, but determined for an area derived from source area models.
SUEWS Prepare	C/L	Prepares input data for the SUEWS model (processor).
<i>Processor</i>		
ExtremeFinder	C	Heat and cold wave conditions.
Mean Radiant Temperature (SOLWEIG)	L/M	SOLWEIG estimates spatial (2-D) variations of 3-D radiation fluxes and the mean radiant temperature (T _{mrt}) in complex urban settings.
Anthropogenic Heat (LQF)	C/L	Globally applicable method (low spatial resolution) to calculate QF
Anthropogenic Heat (GQF)	C/L	Locally applicable method (high spatial resolution) to calculate QF
Urban Energy and Water Balance (SUEWS; Simple)	C/L	Urban land surface model of radiation, energy and water fluxes for a single point or area.
Urban Energy and Water Balance (SUEWS; Advanced)	C/L	As above, but for multiple areas.
Solar Energy on Building Envelopes (SEBE)	L/M	Shortwave irradiance on ground, roofs and building walls.
Daily Shadow Patterns	L/M	Shadow maps are derived from buildings and 3D vegetation.
<i>Post-Processor</i>		
SEBE (Visualization)	L/M	Visualization of solar irradiation on building envelopes i.e., both roofs and walls.
SOLWEIG Analyzer	L/M	Analyzing output from the SOLWEIG model.
SUEWS Analyzer	C/L	Analyzing output from the SUEWS model.
Benchmarking	C/L/M	Statistical tool to compare different datasets

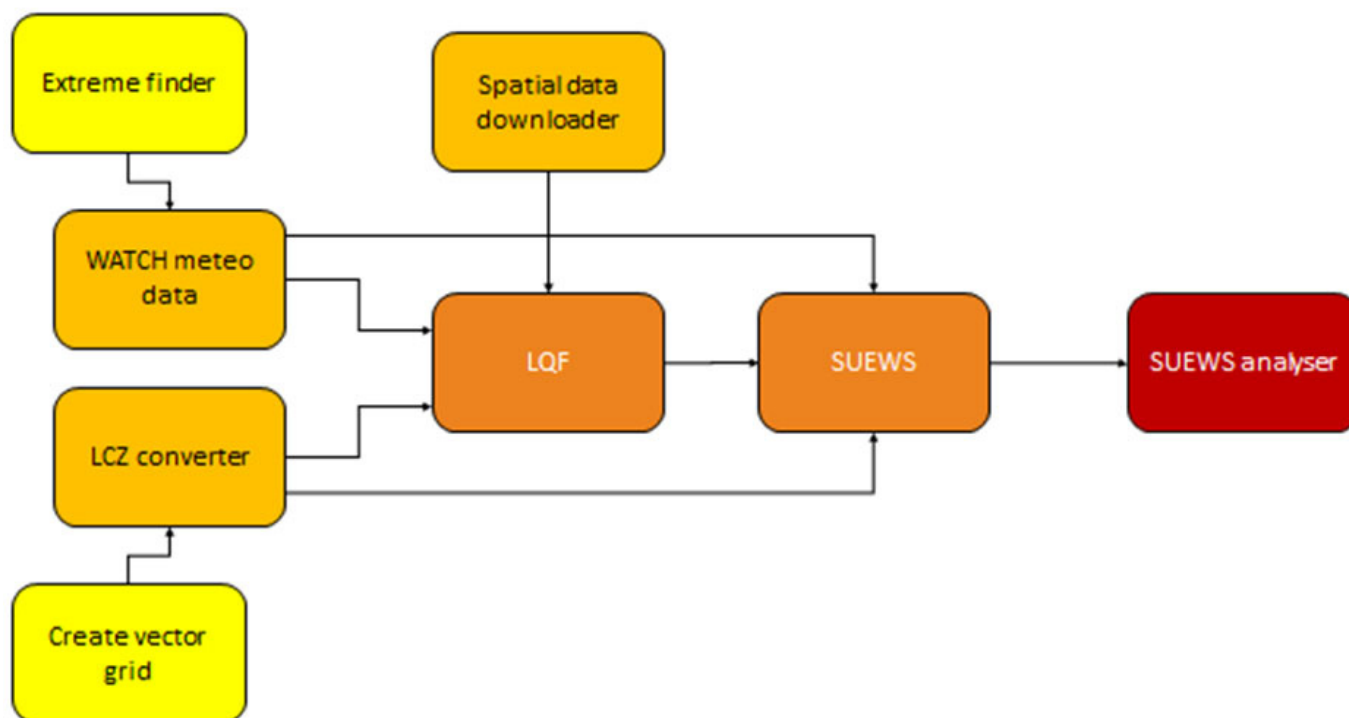


Figure 2. Workflow of an urban energy and water balance application.

Application examples

Energy and water balance fluxes for Beijing, China

Energy and water balance fluxes are critical to surface-atmosphere interactions in an urban area. The impact of extreme conditions (heat waves, droughts, floods etc.) are influenced by the state of the urban environment prior to these events, with the urban energy and water balance flux partitioning varying with different neighborhood characteristics. The Surface Urban Energy and Water balance Scheme (SUEWS) is a core urban land-surface model included in the processing part of UMEP (Table 1). The model simulates the urban radiation, energy and water balances using commonly measured meteorological variables and information about the surface cover. SUEWS is applicable at the local (neighborhood) to city scale. UMEP has the latest version of SUEWS ([v2017b](#)) accessible through two links:

a) **SUEWS Simple** is intended to provide a useful starting place to introduce UMEP and SUEWS. Example data are provided so that the user can explore the impact of modifying urban surface characteristics. With SUEWS Simple, the ULSM can be executed for a single location (area).

b) **SUEWS (Advanced)** provides a full version of the model appropriate for both spatial and temporal investigation of the urban energy balance.

The SUEWS model has been extensively evaluated at various locations and situations worldwide (see Lindberg et al. 2018).

In this example the implication of a heat wave event compared to a 'normal' summer month is compared with

regards to sensible heat flux over Beijing, China. The workflow for this application is outlined in Figure 2. Geo-datasets that contain information about the urban environment are used with the pre-processor tools to provide the required surface parameters. It is strongly recommended that all geodata used are transformed into the same projected coordinate system. The model can be applied to areas of any shape, here referred to as 'grids'. These areas need to be defined in a vector polygon layer. In most cities, there will be planning units with known boundaries already available in this format (e.g. boroughs, wards). In this example a square grid is created in QGIS, e.g. by using *Vector > Research Tools > Vector grid*.

As land cover is a key characteristic for many calculations, a method to reclassify data is provided (**Land Cover Reclassifier**). In this application example, no specific spatial input data exists and thus other sources of information are required. Accessing reliable sources of land cover information to derive these parameters at the scale of interest remains a challenge. Crowd-sourced data sets such as *OpenStreetMap* (<http://www.osm.org>) and *WUDAPT* (<http://www.wudapt.org/>) offer potential but may be incomplete or inconsistent. In this example, Local Climate Zones (Stewart and Oke 2012) are used to derive land cover information using the **LCZ converter** available from the UMEP pre-processor. This tool converts WUDAPT data into input information for SUEWS (Figure 3).

Morphometric parameters required as model input can be calculated using the Morphometric Calculator (Grid) using digital surface models (DSM). From these data, the

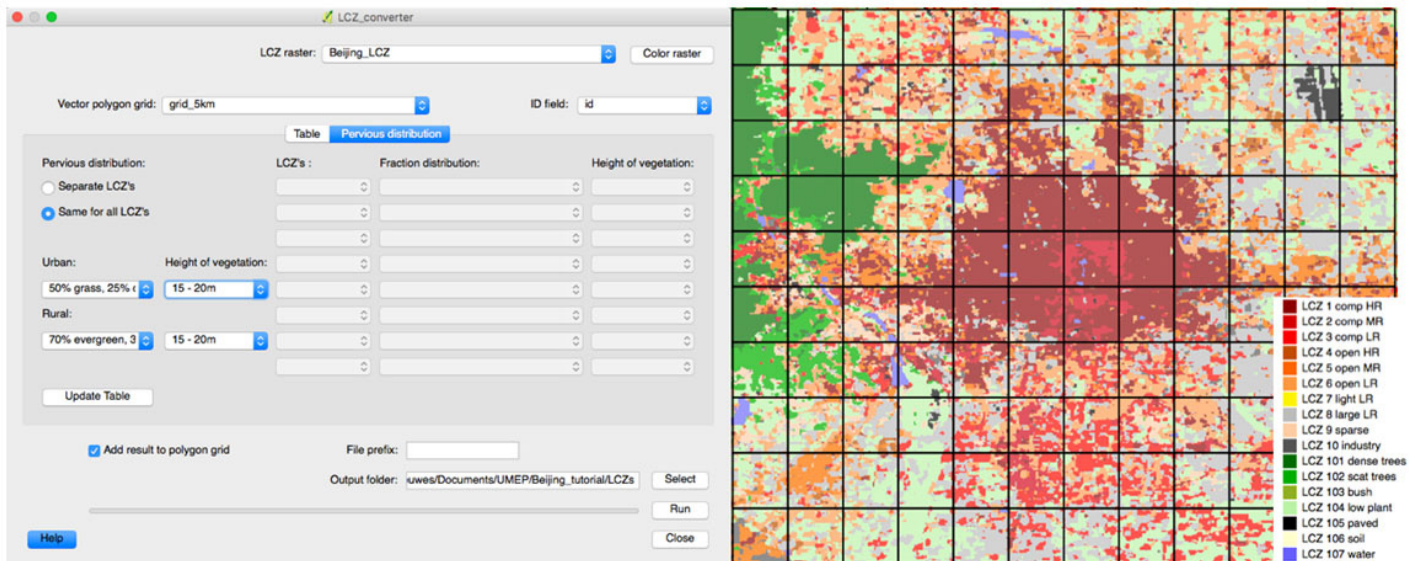


Figure 3. The LCZ Converter interface in UMEP (left) and Beijing LCZs (right) derived from the WUDAPT database (Ching et al., 2017). Each grid is about 5 km².

zero-plane displacement height (z_d), aerodynamic roughness length (z_0) and other geometric parameters such as mean roughness-element height and frontal area index can be calculated (Kent et al. 2017a,b). In this application example this information is parameterized from the WUDAPT LCZs. However, if more detailed information is available, this can be utilized.

Population density is used in the estimation of anthropogenic heat flux in SUEWS. In this example population density datasets are unavailable (e.g. as would be obtained from local census data), so the **Spatial Data Downloader** can be used. This plug-in is directly connected to various spatial datasets including global datasets on population density. Population information needs to be (dis-)aggregated based on the polygon grid. This is preferably done using e.g. the built-in tool *Zonal statistics* in QGIS.

The other major input is the forcing meteorological data. This needs to be for above the height of the roughness elements (trees, buildings). A common format is used in all UMEP models but unnecessary data for a specific application does not need to be supplied. Most applications require a continuous gap-filled data set. For many urban applications, the impact of daylight savings starting and finishing is important. This results in a distinct movement of human activities (e.g. commuting time) which cause changes in anthropogenic heat emission times.

In this example, the **ExtremeFinder** is used to identify years with 'normal' and 'heat wave' summer situations for Beijing (Figure 4). 2006 was identified as a 'normal' and 2009 as a 'heat wave' summer. When the years of interest have been identified, the **WATCH data** plugin in UMEP is used to retrieve data from the years of interest. UMEP allows the user to draw on the reanalysis dataset, WATCH Forcing Data ERA-Interim (WFDEI) (Weedon et al. 2011,

2014). This product was selected as it was designed to be used for hydrological and land-surface modelling for climate purposes. It is derived from the ERA-Interim reanalysis product (Dee et al. 2011) via sequential interpolation to half-degree spatial resolution with 3 h temporal resolution (Weedon et al. 2011, 2014).

Once all the required information has been pre-processed, the SUEWS model can be executed through the UMEP processor. Results from two example model runs are shown in Figure 5 where the increase in sensible heat (Q_H) during a 'heatwave' year is evident. The two maps are generated using the **SUEWS Analyzer** in the post-processor section in UMEP. This enables simple exploration of spatial and temporal model results.

Other examples of UMEP applications

The contrast between sunlit and shaded surfaces can explain micro-scale differences in urban climate, for example spatial variation in road surface temperatures (Hu et al. 2016). In UMEP, sunlit fractions are computed using high resolution DSMs and the **ShadowCalculator** plug-in (Figure 6b). Sequential computation of 'shadow volumes' (Ratti and Richens 1990) are generated with a raster DSM. The shadow casting algorithm can also be used to generate sky view factors maps (Figure 6c) (**SkyViewFactorCalculator**) used for various urban climate related applications (Lindberg and Grimmond 2010).

Temperature-related health problems are expected to increase with rising temperature in cities, especially during more extreme temperatures during heat waves. Mean radiant temperature (T_{mrt}) is one of the most important meteorological variables governing the human energy balance and thermal comfort outdoors, especially on clear and calm summer days (Mayer and Höppe 1987). Within the UMEP framework, the **Mean Radiant Tempera-**

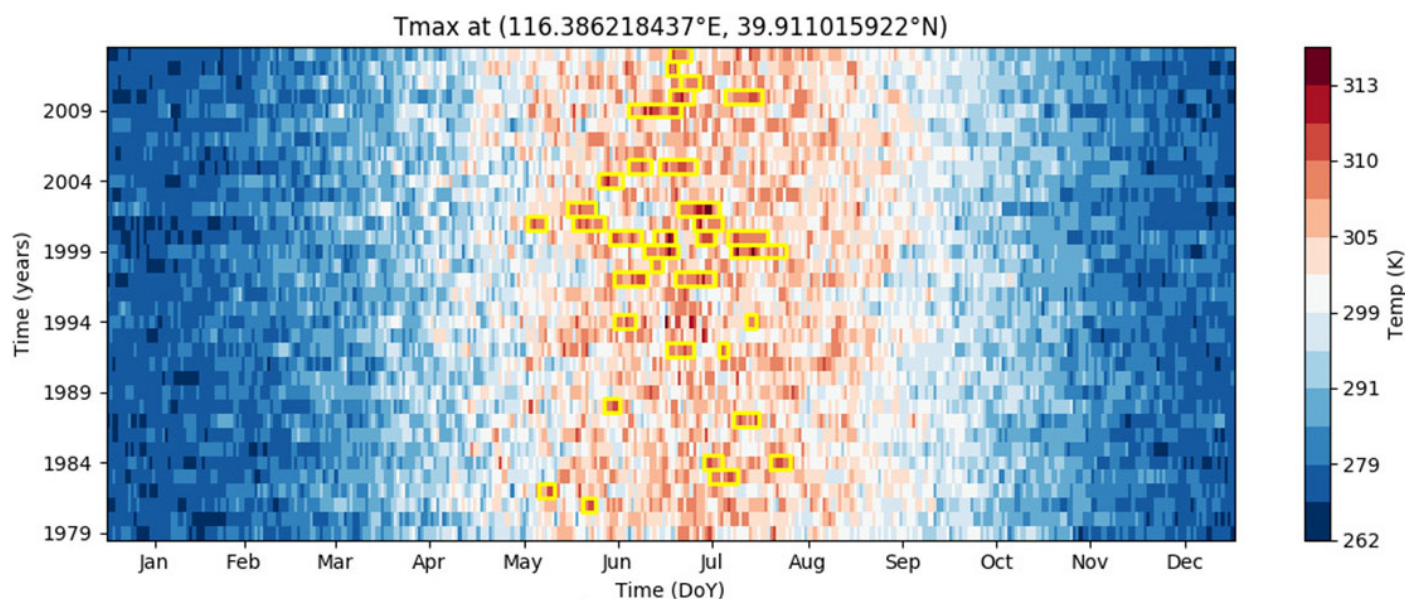


Figure 4. Output from the ExtremeFinder where yellow boxes are identified as heat wave periods.

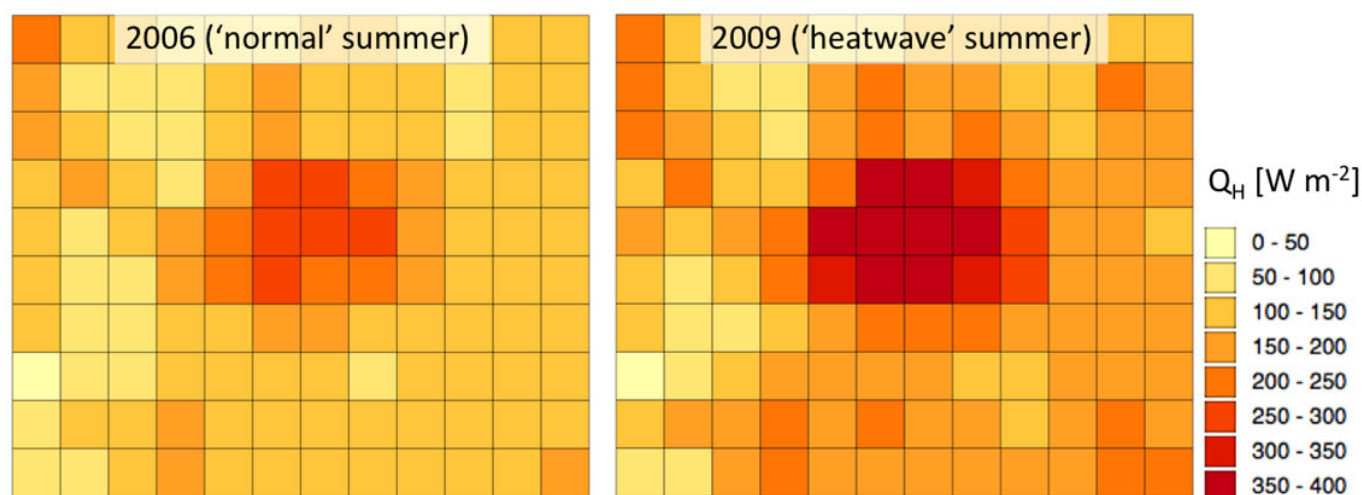


Figure 5. Mean sensible heat flux at 13:00 local time during July for Beijing, China (5 km resolution).

ture (SOLWEIG) plug-in can be used to calculate T_{mrt} and thus provide estimates of thermal comfort/heat stress for people (Figure 6d). Both 3D vegetation (trees and bushes) as well as variations in ground cover can be considered (Lindberg and Grimmond 2011; Lindberg et al. 2016). SOLWEIG has been extensively evaluated and applied at urban locations worldwide (see Lindberg et al. 2018).

For solar energy planning, and to map potential solar energy production, SEBE (Solar Energy on Building Envelopes) has been developed to calculate irradiances on buildings structures for several cities in Sweden (see Lindberg et al. 2018). Pixel resolution solar radiation on building roofs and walls is simulated by the 2.5-dimensional model SEBE. Observed solar radiation data are used with high resolution DSMs to derive accurate irradiances for the surfaces modelled (Lindberg et al. 2015).

Summary and future prospects

The city based climate service open source tool UMEP

(Urban Multi-scale Environmental Predictor) is demonstrated with a series of applications. Applications related to outdoor thermal comfort, urban energy consumption, climate change mitigation, etc. are already available. UMEP is under active development and refinement.

The development team welcomes all kinds of collaboration through, for example, submission of comments or issues to the repository (https://bitbucket.org/fredrik_ucg/umep), participation in coding, addition of new features and development of new tutorials for users.

The online manual provides more details on how to participate (<http://www.urban-climate.net/umep>).

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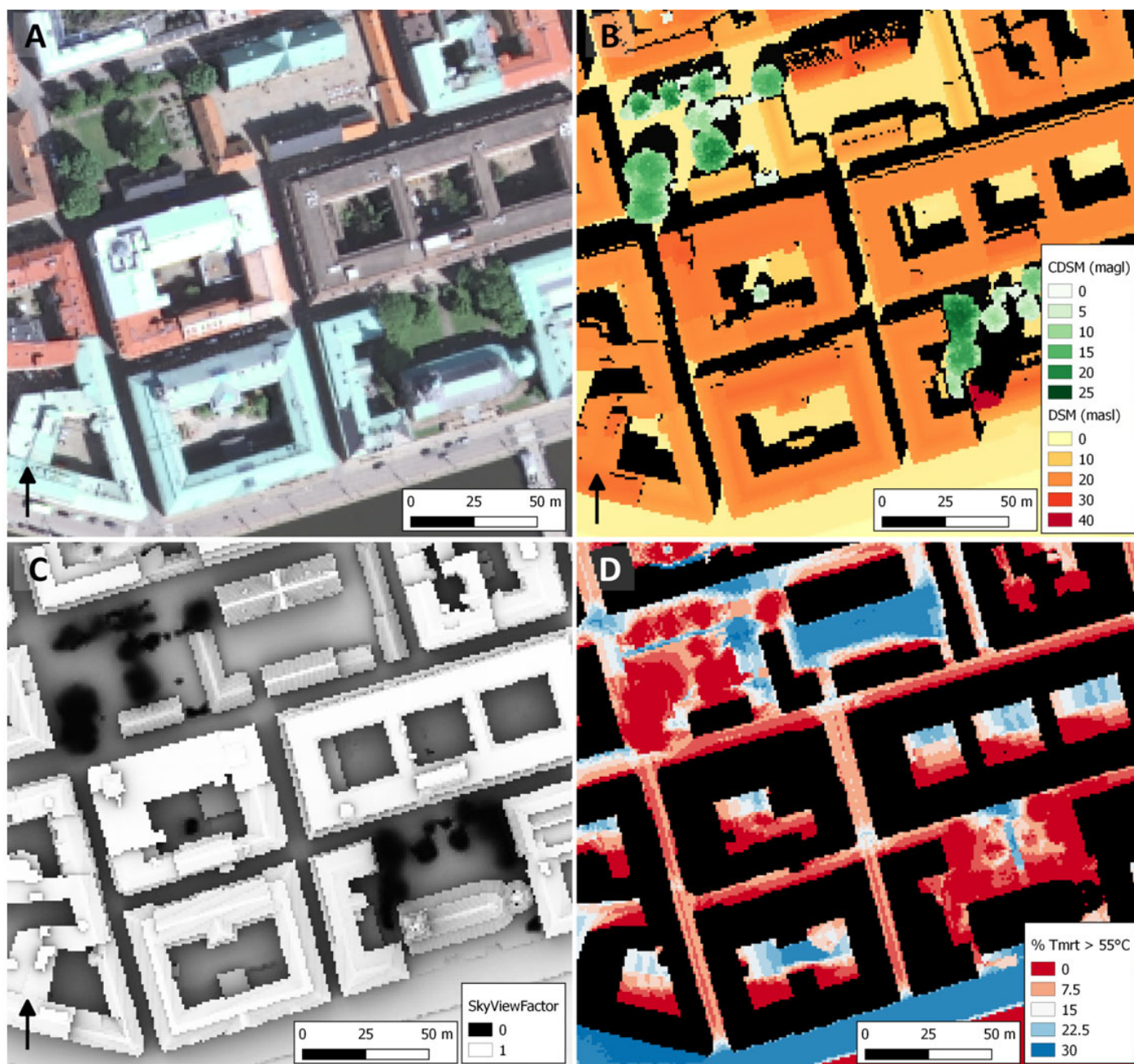


Figure 6. Examples of UMEP applications. (a); Aerial photo over central parts of Gothenburg, Sweden, (b) Digital surface models (DSM and CDSM) overlaid with generated shadow patterns (black areas) for 8 May (1 pm), (c) sky view factor from buildings and vegetation, (d) Percent of time on 26 July 2006 when $T_{mrt} > 55^\circ\text{C}$. The pixel resolution here is 1 m.

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Single-column Urban Boundary Layer Inter-comparison Modelling Experiment (SUBLIME): Call for participation

Urban areas are expanding globally and, in combination with an increase in heat waves due to a warming climate, they experience pressure concerning i.e. environmental quality, human health and energy consumption. Numerical weather prediction (NWP) models now reach a spatial grid resolution at which cities and even contrasting neighbourhoods are becoming visible in the model land surface map and the characteristics at such scales might be used increasingly for urban planning purposes. Hence, there is a clear need to develop and evaluate urban land-surface schemes and to understand their key driving parameters. In this paper, we present the setup and research questions for a Single-column Urban Boundary Layer Inter-comparison Modelling Experiment (SUBLIME), and invite the community to participate.

The SUBLIME project builds upon the earlier urban land-surface model inter-comparison by Grimmond et al (2011). Grimmond et al. (2011) evaluated urban land-surface models in offline mode, i.e. driven by observations at a height that is typical for a NWP first atmospheric model grid level. Generally speaking, it was found that higher complexity did not necessarily guarantee a better performance when compared to observed surface fluxes. Key aspects for a good model performance appeared to be the representation of vegetation in urban areas and the inclusion of an anthropogenic heat flux. In addition, the model sensitivity to land surface and morphological parameters was quantified. In the SUBLIME project, we study whether these findings are confirmed in the case where the urban land-surface model is coupled to the overlying atmospheric boundary layer allowing for a comparison closer to NWP applications. Moreover, the SUBLIME project provides a benchmark for future model evaluation and further development.

A case study was prepared during the workshop, "eWUDAPT: Bringing science to urban climate mapping and modelling" held in June 2017 in Leiden (Netherlands). The goal of the workshop was to combine different urban expertise (geography, meteorology, data science, observations) with eScience expertise to provide better understanding of urban environments and improve weather forecasts. Within the context of this workshop, a team dedicated to urban modelling performed an initial model inter-comparison study focused on the inter-



Figure 1. Land cover map (based on OS MasterMap) of central London study area with measurement site locations. Inset shows study area within Greater London in Southeast England.

action between urban surface energy balance schemes and boundary-layer schemes. Based on the initial results, we have formulated an inter-comparison study that aims to, firstly, unravel the interactions between urban surface characteristics and boundary-layer dynamics and, secondly, investigate the sensitivity in the coupling of these two components in different models. The participating institutes will be asked to run their urban-canopy model and single-column model (SCM) for a specific case study. The project contains two phases, each consisting of three stages where different degrees of detail concerning the urban land surface are provided. Below we present a selected case study and the modelling strategy. Details concerning the settings are provided in a word document on the website <http://www.met.wur.nl/sublime>.

Selected case study and site description

Central London is here chosen as the study area due to detailed observations being available (including those from the London Urban Meteorological Observatory (LUMO) network (<http://micromet.reading.ac.uk/>) and the ClearLo measurement campaign (Bohnenstengel et al, 2015)). The observations used are turbulent surface fluxes and radiation fluxes measured at the KSS site (Fig. 1, Kotthaus and Grimmond, 2014), mixed-layer height (MLH) derived from profile observations by a ceilometer (Kotthaus and Grimmond, 2017, submitted) located at the MR site (Fig. 1), and wind speed observations from Doppler-lidar systems at the NK site (Fig.1). The area has been

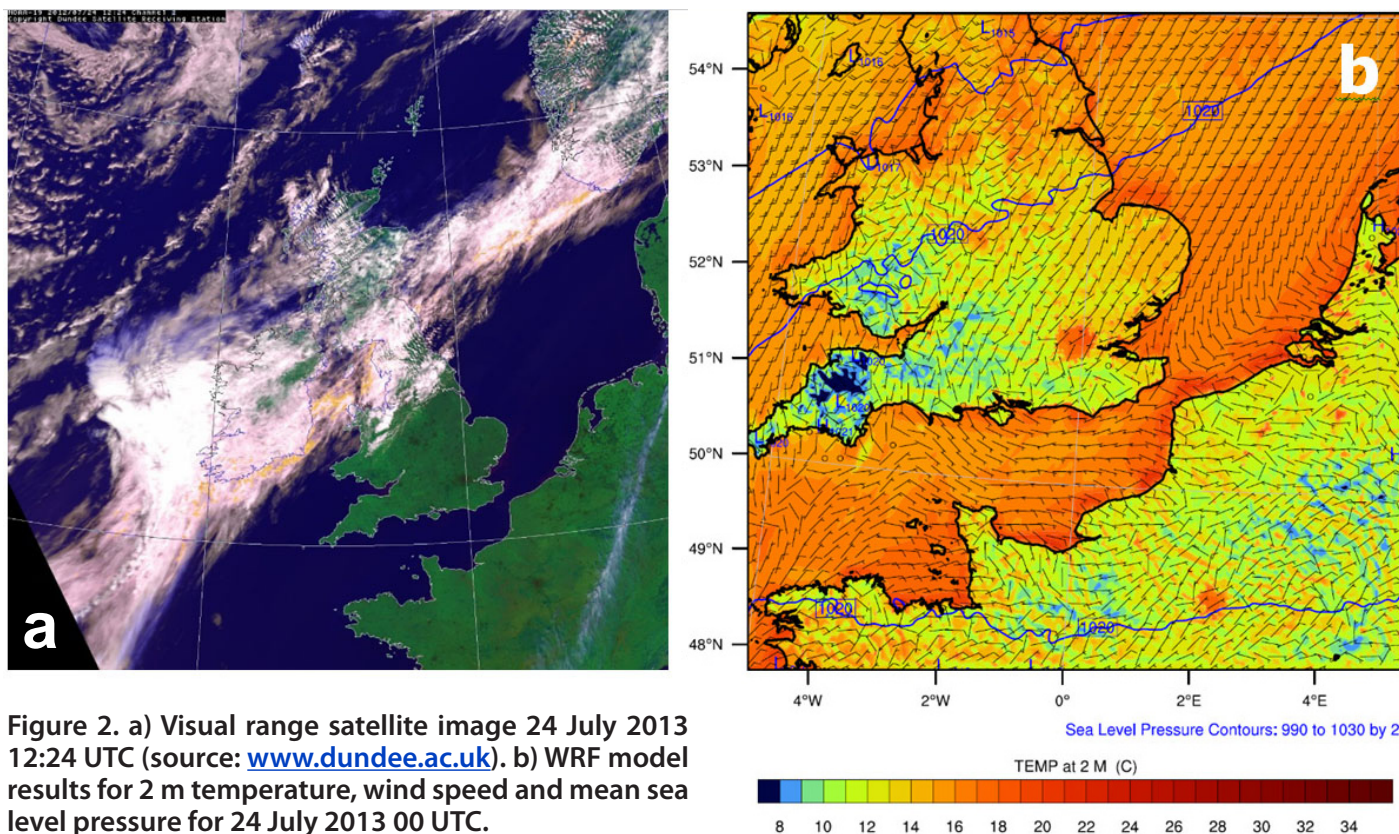


Figure 2. a) Visual range satellite image 24 July 2013 12:24 UTC (source: www.dundee.ac.uk). b) WRF model results for 2 m temperature, wind speed and mean sea level pressure for 24 July 2013 00 UTC.

categorised as local climate zone ‘compact midrise’, and is characterized by taller buildings amidst midrise building stock. Land cover is mostly paved and buildings are constructed with stone, brick, tile, and concrete. Concerning case selection criteria, our goal was to select a period with relatively simple weather conditions dominated by local forcing processes, for which urban canopy schemes are expected to be particularly useful. Given these constraints (relatively weak synoptic forcing, cloud-free, sufficient observational data availability) the case of 23 July 2012 00 UTC to 25 July 2012 06 UTC, i.e. a period of 54 hours covering two nights, was selected. Satellite imagery revealed London was cloud-free for the full period (Figure 2a).

WRF mesoscale model simulations were performed at 2.5 km horizontal grid spacing in order to quantify the evolution of the geostrophic wind speed and direction, vertical wind speed, and advection rates of potential temperature, humidity and momentum. Figure 2b shows that WRF forecasts a well-developed urban heat island effect of about 5 K at midnight. Doppler lidar observations taken at NK (Figure 3) show that initially the wind direction is predominantly southerly, wind speeds are about 4 m/s and the Atmospheric Boundary Layer (ABL) is generally well-mixed. In the evening and night the wind speed drops to ~1 m/s increasing again to ~2 m/s during the next day. Interestingly the wind direction at the end of the afternoon veers towards southerly which suggests the influence of a sea breeze. The derived MLH reaches up to 1250 m and 2000 m during the first and second day respectively.

Forcings

Based on WRF simulations, the study period is characterised by an initial geostrophic wind forcing of 5.5 m/s for the u - and 1.5 m/s for the v -component in the ABL (Fig 4). The initial geostrophic wind speed is almost uniform with height, while for the v -component we observed a decrease with height and also a shift in direction from southerly to northerly flow at about 4 km. However to simplify the setup, both components of the geostrophic wind speed are assumed uniform with height. The u -component of the geostrophic wind reduces considerably over time, i.e. from 5 m/s to ~0 m/s at the end of the study period. The v -component remains relatively stationary, (~2 m/s), reducing only in the last night. Overall, there is a change in the mean surface wind direction from SW to SE during the 54 hours of this study.

The initial profiles for the case study are presented in Fig 5. The u -component of the wind speed follows an approximately logarithmic increase with height to 5.5 m/s, matching the geostrophic wind speed aloft. The v -component shows a slight low-level jet of 0.5 m/s and then reaches 1.5 m/s aloft to match the geostrophic wind speed. As the case starts at night, the initial potential temperature profile increases slowly with height. Specific humidity is almost uniform below 800 m. The initial turbulent kinetic energy is concentrated close to the ground and diminishes to zero at about 500 m.

SCMs require lateral forcings to account for advection of heat, moisture and momentum, here derived from WRF

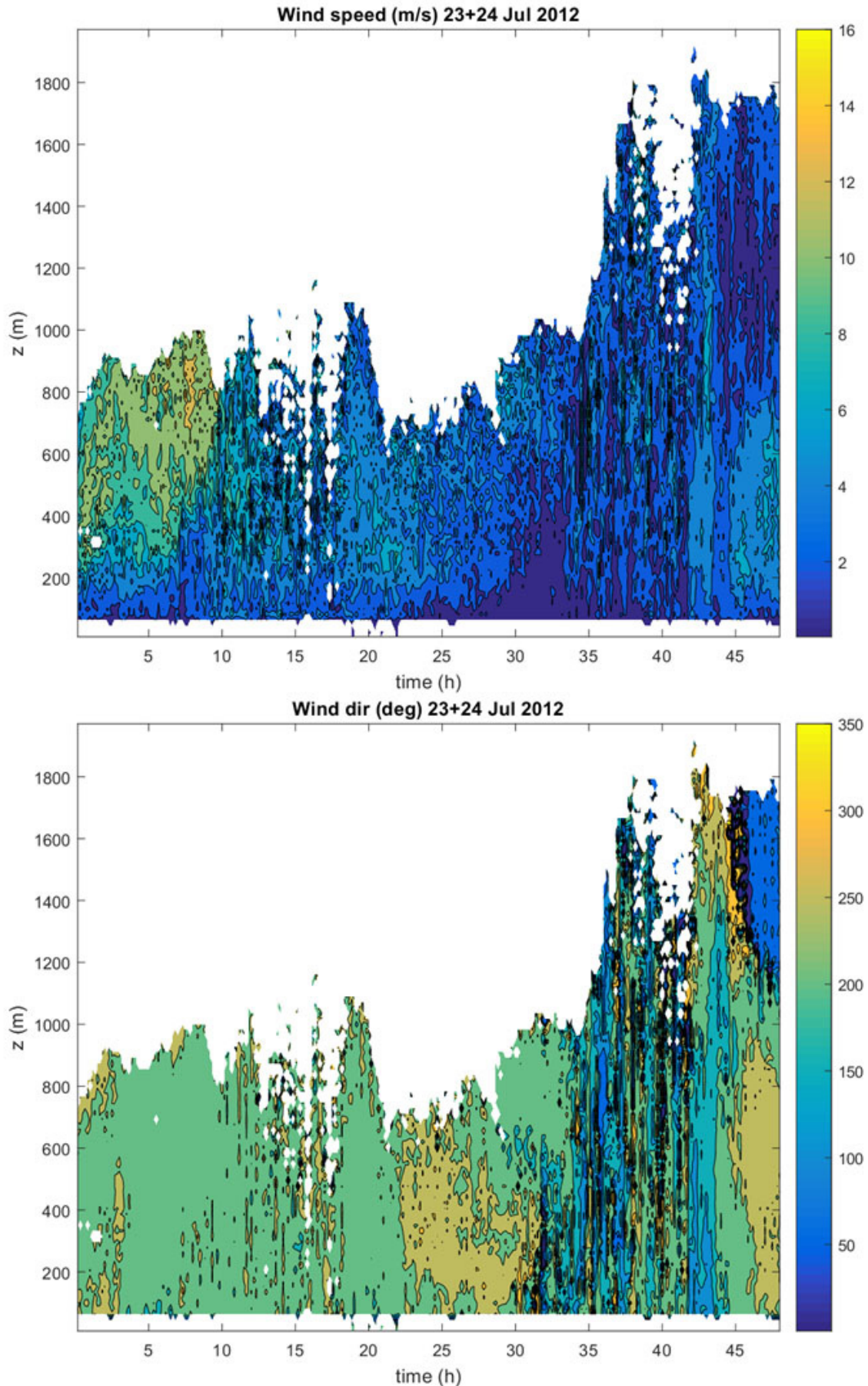


Figure 3. Observed wind speed (top) and direction (bottom) as observed by the Doppler lidar during 23-24 July 2012 at the North Kensington site (London).

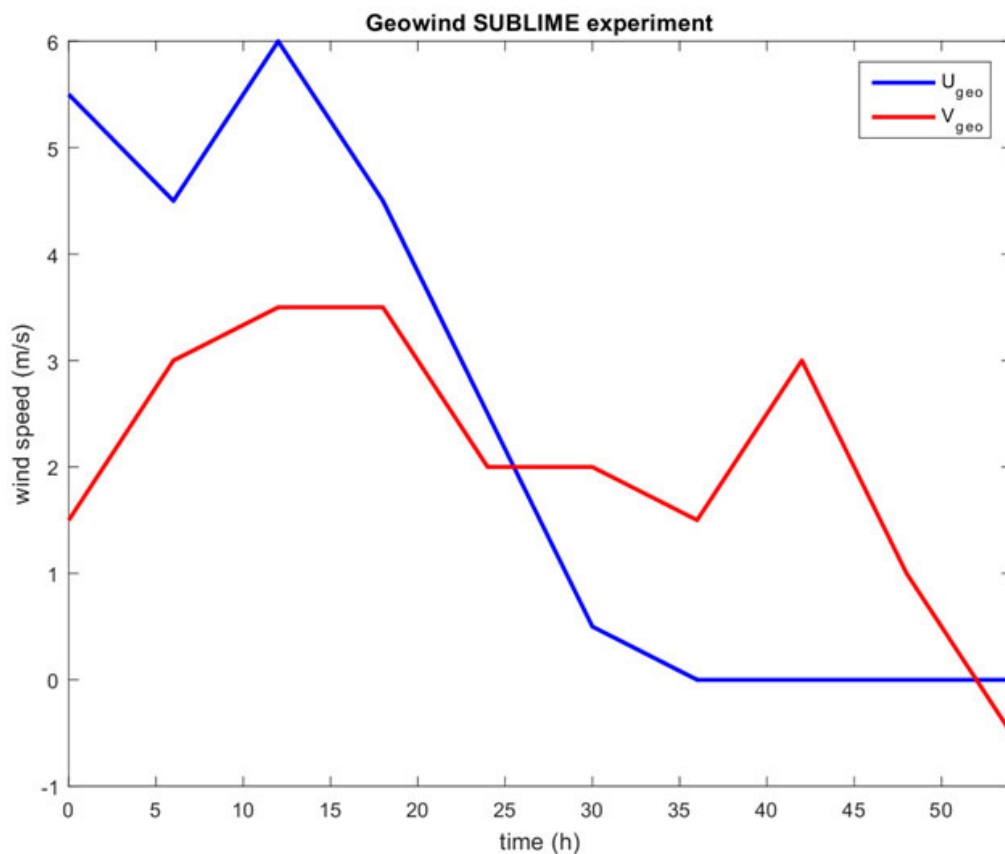


Figure 4. Evolution of the prescribed geostrophic wind speed during 23-24 July 2012.

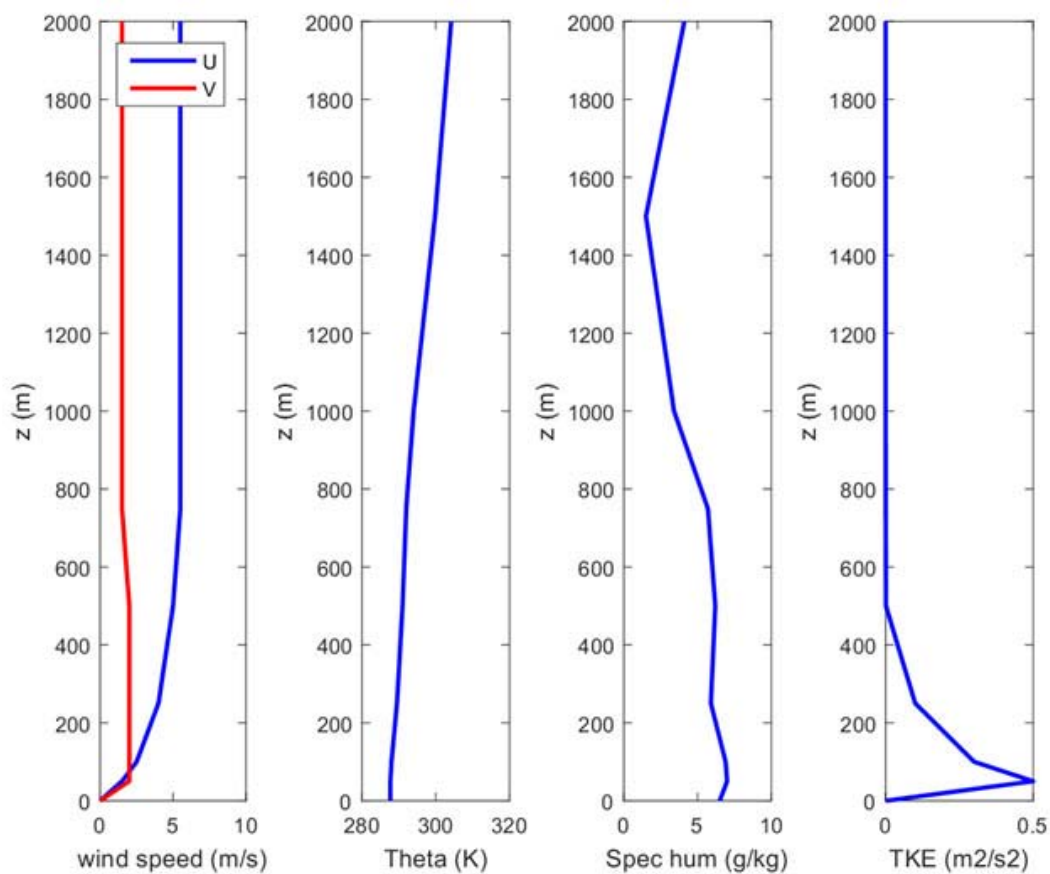


Figure 5. Initial profiles for wind speed components, potential temperature, specific humidity and turbulent kinetic energy.

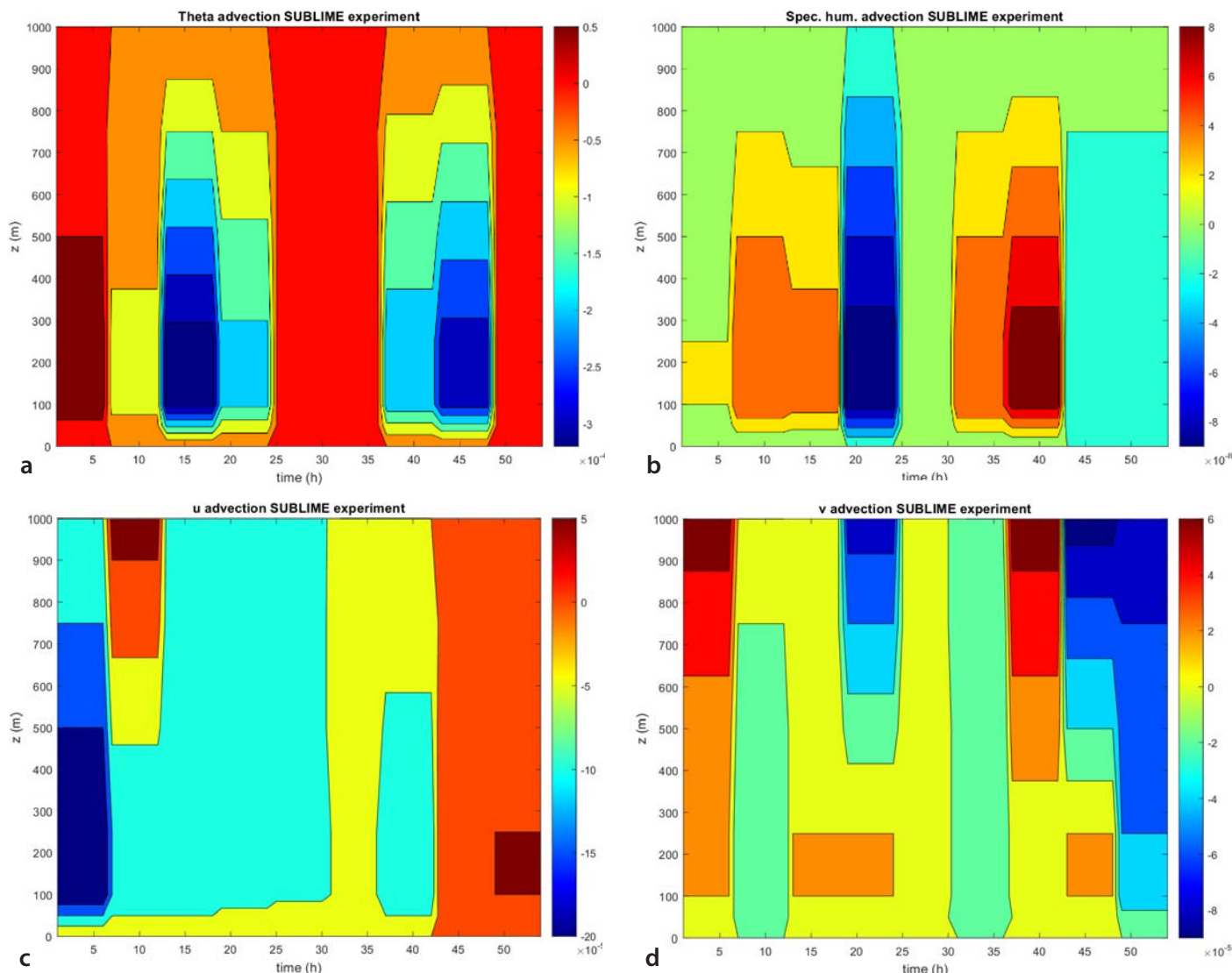


Figure 6. Spatiotemporal evolution of the advection for potential temperature (a, unit: K/s), specific humidity (b, unit kg/kg/s), and momentum (c and d, unit m/s²).

simulations. These have been evaluated against advection estimates using the UK Met Office (UKMO) automated weather stations in and around London. Figure 6 shows the simplified advection fields during the study period. We prescribe a diurnal cycle of heat advection, during daytime when the advection is rather small and cold air advection in the afternoon, in order to represent the urban breeze. This coincides well with the advection of the *v*-component. In addition, dry air advection is present at the end of the first day, while moist air advection occurs at the end of the second day.

Experimental set up

The model experiment consists of two phases, each containing three stages. Phase 0 consists of the evaluation of the urban canopy models decoupled from the atmospheric boundary layer. The models are forced by observations of temperature, specific humidity, wind speed and direction, and short- and longwave downwelling radiation. This comparison is as such similar to the PILPS-urban model ex-

periment in Grimmond et al. (2011). In Phase 1, the urban canopy models are coupled to a single-column model for the atmospheric boundary layer, and hence become interactive. By comparing the results of the two phases we can learn about the difference in model behaviour between coupled and offline mode.

The different stages assess the impact on model performance of the level of detail about urban morphology that is provided. In Stage 0, the urban canopy models are run without any detailed knowledge of the site of interest and are run with their respective default values that one would apply without further knowledge, e.g. the WRF model would use the settings for morphological and building parameters of North-American cities. In Stage 1, information similar to the Level 0 of the WUDAPT project, i.e. only Local Climate Zone information, is provided. Finally, in Stage 2 the models will be provided with detailed information about the urban morphology for the site. The sequence of stages will unravel the impact of the degree of detail about urban morphology on the model weather forecast.

Analysis

The submitted model results from each participating land surface scheme will be evaluated against observations of the thermodynamic evolution as well as radiation and turbulent surface fluxes at the surface. Note that all model results will be presented in an anonymous way. The variability of the model results will be analysed with regards to the complexity of the model formulations. Amongst others, the process diagram approach of Sterk et al. (2013) will be utilized to investigate which of the physical processes or model parameters induce the variability detected. In these diagrams the values of forcing processes and resulting variables are plotted, e.g. net radiation versus temperature after a certain simulation time, as well as for the observations. Also, within one model the resulting state after varying the intensity of transport processes (e.g. radiation, turbulent transport, heat conduction in urban fabric) will be displayed. Combining these values, we can unravel which physical processes are responsible for the variation in the participating models.

If you would like to participate in the SUBLIME study, please contact Gert-Jan Steeneveld (Gert-Jan.Steeneveld@wur.nl) or Aristofanis Tsiringakis (Aristofanis.Tsiringakis@wur.nl)

Time frame – Oct 15, 2017: Release of case study. May 1, 2018: Deadline for submission of model runs by participants. Aug 2018: Presentation & discussion of further steps at ICUC10.

Website – All information concerning the modelling recipe is available on the website www.met.wur.nl/sublime. A pdf with modelling instructions, settings per phase, and forcing datafiles (netcdf format) to feed the models is provided.

Acknowledgements – The authors acknowledge support from the Lorentz Center (Leiden, Netherlands) and the Netherlands eScienceCenter for the workshop “eWUDAPT: Bringing eScience to Urban Climate Mapping and Modelling” in which the project was formulated.

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Crowdsourcing urban air temperatures from citizen weather stations

Introduction

Due to high spatial and temporal variability of urban climates, dense sensor networks are needed to observe and study atmospheric conditions in cities. However, the trade-off between network density, sensor accuracy, and maintenance costs of instruments remains a major limitation in urban climate research (Chapman et al. 2015). The current state of urban atmospheric observation networks is discussed by Muller et al. (2013), referring to high-density networks like the Birmingham Urban Climate Laboratory (Warren et al. 2016), the network of sensors in the Tokyo metropolitan area (Honjo et al. 2015) or the Oklahoma City Micronet (Basara et al. 2010), among others. Their review shows that acquisition of observational data at high spatial resolution to adequately represent spatio-temporal heterogeneity of urban air temperatures (T) is still challenging, particularly over longer time periods. One alternative approach to acquire atmospheric data at high spatial resolution is the use of data from meteorological stations maintained by citizens, also called 'citizen weather stations' (CWS). A number of studies showed the potential of using such data for scientific applications (Steenefeld et al. 2011; Wolters and Brandsma 2012; Bell et al. 2013; Chapman et al. 2017; de Vos et al. 2017).

Since the end of 2014 we continuously acquire freely-available CWS data in order to explore the potential of this novel data set for monitoring and analysis of urban climates in the city of Berlin, Germany, and surroundings. Our main goals are to develop an automated work flow for collecting CWS data, to identify typical error sources that are associated with these data, and to develop and carry out a comprehensive data quality assessment (QA). Finally, we aim at investigating spatio-temporal characteristics of crowdsourced T , using urban morphology and land-cover data as well as the Local Climate Zone (LCZ) classification scheme (Stewart and Oke 2012) to characterize CWS in terms of their local-scale surroundings. Thus, potentially hundreds of measurement sites enable investigation of inter- and intra-LCZ T differences at the same time, which is not possible with only a few measurement sites. This article summarises our research up to now. For more details the reader is kindly referred to Meier et al. (2017) and Fenner et al. (2017).

Crowdsourcing and availability of CWS

The term 'crowdsourcing' expresses the acquisition of large amounts of data from an undefined crowd of citizens who share their data from CWS that are connected

to the internet. Our studies are based on crowdsourced T originating from 'Netatmo' weather stations (<https://www.netatmo.com/>), which can be bought by citizens across the globe to monitor indoor and outdoor atmospheric conditions. Main advantages of Netatmo CWS are the consistent use of the same type of sensors with the same technical specifications in all stations, high spatial density and coverage in many urban areas, and an application programming interface (API) provided by the company allowing for easy data access. The CWS itself consists of two modules, one of them measuring indoor atmospheric conditions, while the other one measuring outdoor T and relative humidity at approximately five-minute intervals. The CWS owner can directly access the data via a smartphone application or by an internet browser, and can decide to share the outdoor data publicly. Shared data are then displayed on the 'weathermap' (<https://weathermap.netatmo.com/>) and can be collected by other users via the Netatmo API.

We have set up a workflow that automatically collects CWS data via the Netatmo API at hourly resolution. The data returned by the API are the last instantaneous values provided by the stations. These data are checked for consistency prior to writing them into a local data base. Figure 1 provides an overview of all available CWS on 1 December 2017 at 10:00 h UTC for Berlin, Germany, and Paris, France, showing that 1934 stations are within a 40 km x 40 km domain of Berlin and 5314 stations are within the domain of Paris. The spatial density of stations is especially high within the city centres, in some parts of Paris as high as 43 stations per km². However, stations are not limited to dense urban areas. A large number of CWS is located within sub-urban and rural environments, though always located close to habitation since private Wi-Fi connection is required for uploading data.

Error sources, quality assessment and data filtering

Data quality plays a key role for meaningful data analyses, and this remains the biggest challenge when using crowdsourced data (Bell et al. 2013; Muller et al. 2015; Chapman et al. 2017). First, the Netatmo sensor itself could be the source of measurement errors. However, we could show with comparative measurements of eight Netatmo stations inside a climate chamber that the sensors comply with the manufacturer's specified accuracy of ± 0.3 K for the T range 0 - 30°C (slight warm bias around 0.4 K for four of the sensors at 0°C). Recently conducted comparative measurements in the climate chamber showed that after two years in use Netatmo

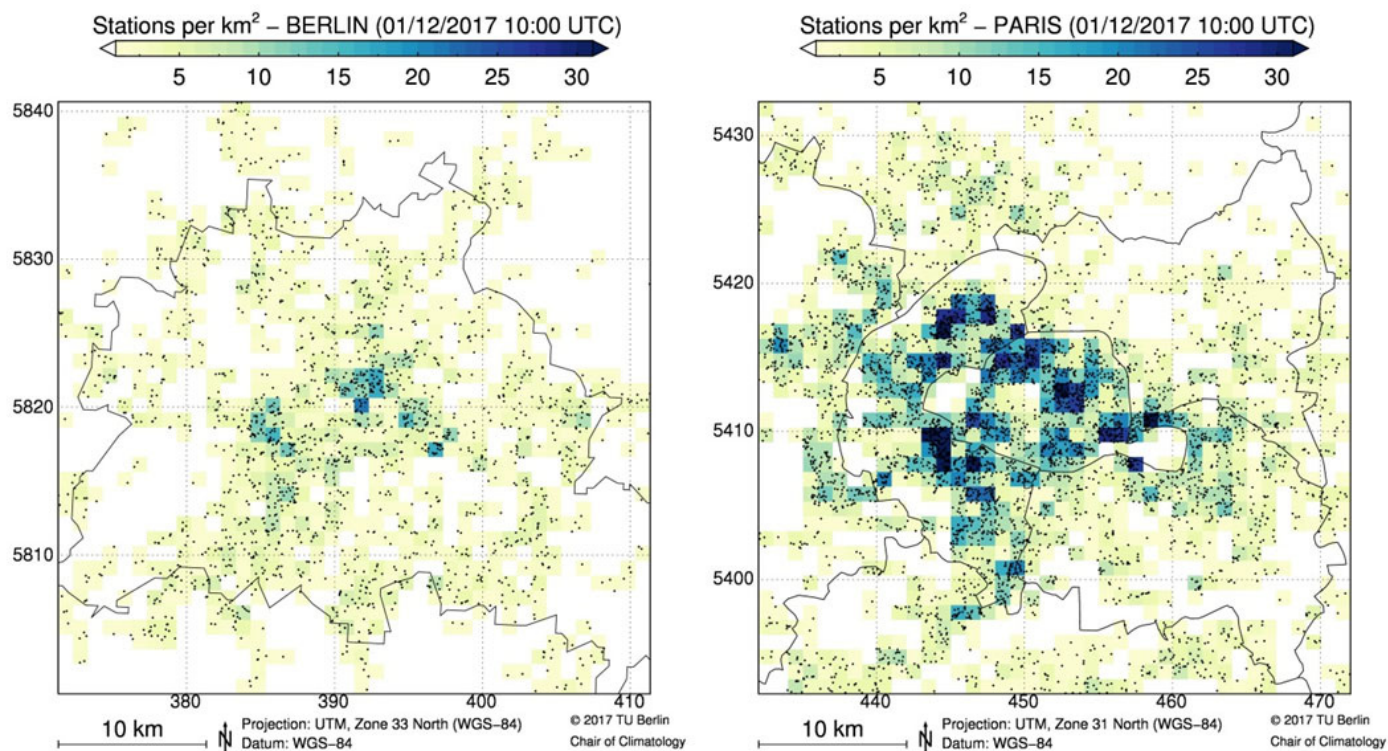


Figure 1. Locations of Netatmo stations (black dots) and spatial density per km² on 1 December 2017 at 10:00 h (UTC) for Berlin, Germany (left) and Paris, France (right).

outdoor sensors are within the accuracy range, though the warm bias for 0°C still exists. Taking other potential error sources that are associated with CWS into account, we developed a systematic and comprehensive QA procedure for Netatmo T (Table 1). Data collection failure due

to hard- and software errors can significantly reduce data availability especially if robust daily and monthly values are needed (QA level A2 and A3). However, these problems can be solved by improved server technologies or the use of alternative API programs. Errors caused by user

Table 1. Data quality levels, criteria for data filtering, potential error sources for crowdsourced air temperature (T_{crowd}), and data availability in the Berlin study area at each level for 2015 (adapted from Meier et al. 2017, updated with data acquired retrospectively in May and August). T_{ref} is air temperature from reference stations.

Quality Level	Description of criteria for data filtering	Potential error sources	Percent of raw data
A0	T_{crowd} with correct timestamp	Netatmo API and server limits	100.0
A1	Invalid metadata (latitude, longitude)	User-specific operating error	97.9
A2	80% hourly data per day	Intermittent failure of wireless network, loss of battery power, server failure	92.3
A3	80% daily data per month	Hard- and software problems (cf. A2)	92.3
B	Indoor station filter, using monthly average and standard deviation of daily minimum T	User-specific installation error (misuse), Netatmo outdoor module set up indoors or very close to building walls and windows	67.2
C1	Systematic radiative error filter, positive and significant correlation between global radiation and air temperature difference ($T_{crowd_ID} - T_{ref}$)	Netatmo outdoor module set up in a sunlit location (no radiation shield)	59.4
C2	Single value radiative error filter, flagging day-time values when air temperature difference ($T_{crowd_ID} - T_{ref}$) > 3*SD in T_{ref}	At times the Netatmo outdoor module received direct short wave radiation	53.6
D	Outlier filter based on spatial average of T_{crowd} $\pm 3*SD$ in T_{crowd}	Netatmo outdoor module temporarily moved, other measurement errors	53.5

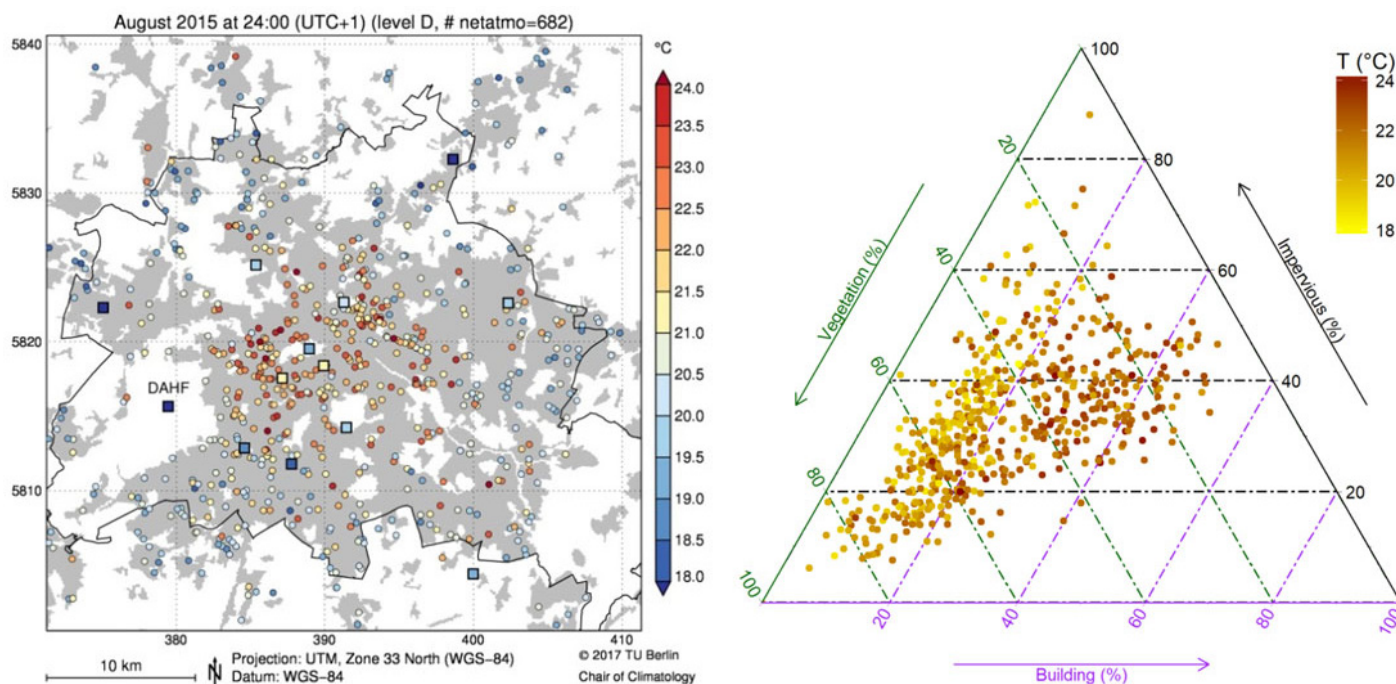


Figure 2. Left: Spatial distribution of mean crowdsourced air temperature (T) measured at Netatmo CWS (circles) and reference T measured at UCON and DWD stations (squares) in Berlin and surroundings during August 2015 at 24:00 h (UTC+1). Right: Ternary diagram of crowdsourced T for surface fractions of building (purple axis), impervious and open ground (black axis), and vegetation and water (green axis) within a radius of 200 m.

behaviour are more difficult to handle. This concerns errors in meta data, i.e., geo-location (QA level A1), inappropriate installation of outdoor module indoors instead of outdoors (QA level B), and unsuitable exposure of sensors to radiation (QA level C). Owners are advised to install a Netatmo outdoor module in a permanently shaded place since it does not have a radiation shield. However, if an owner chooses a location where the outdoor module is exposed to direct short-wave radiation its measurements are subject to radiative errors due to solar heating. For the QA carried out, we used reference data from multiple sites of the Urban Climate Observation Network (UCON) (Fenner et al. 2014), maintained by the Chair of Climatology at Technische Universität Berlin since the beginning of the 1990s, and weather stations maintained by the German Weather Service in and around Berlin for even longer time. The QA assessment procedure can easily be applied to CWS data in other cities, though high-quality reference data in a variety of local settings are needed.

After application of all QA steps, data availability is reduced by about 50% for Berlin in 2015. However, we find good agreement between filtered Netatmo CWS (highest QA level D) and reference data, i.e., deviations of monthly spatio-temporal averages of T are in the range 0.0 – 0.7 K. Further, for individual LCZ classes mean monthly deviations between CWS and reference stations are also within ± 0.3 K, only summer months showing higher differences of up to 1.0 K.

Spatial and temporal analyses

The spatial variation of mean T at 24:00 h (UTC+1) during August is presented in Figure 2 (left, 40x40 km section of the study area). Overall, there are 587 quality-checked crowdsourced stations within the administrative area of Berlin, and 162 stations in the surroundings at this time. The spatial averages of crowdsourced T in Berlin and its surroundings are $21.2 \pm 1.3^\circ\text{C}$ and $19.9 \pm 1.1^\circ\text{C}$, respectively. The night-time pattern of T displays a spatial gradient from the surroundings of Berlin into the city. The inner city neighbourhoods of Berlin are clearly warmer than built-up areas in the outskirts. Figure 2 (right) shows the relation between mean crowdsourced T during August at 24:00 h and land-cover fractions calculated for a radius of 200 m around each CWS. The ternary diagram shows that highest T are observed for building surface fraction $> 20\%$ and vegetation surface fraction $< 40\%$.

When investigating T conditions within different LCZ in Berlin, it becomes clear that CWS are, of course, primarily located in ‘urban’ or ‘built-up’ LCZ classes, while few stations are located in ‘natural’ LCZ. CWS were assigned to LCZ classes based on a city-wide LCZ classification applying the ‘WUDAPT’-method (World Urban Data and Access Portal Tools), a supervised classification method using freely available software and data (Bechtel et al. 2015). The large number of CWS (several hundreds of sites, depending on the month) allows investigating intra-LCZ variability of T , something that is difficult to

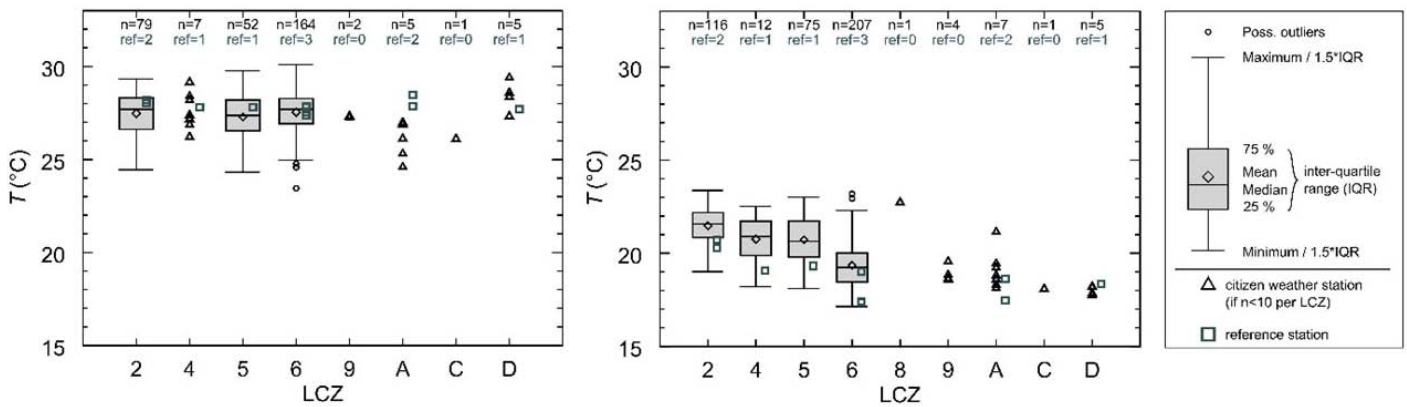


Figure 3. Air temperature (T) distribution for daytime (1300–1600 UTC+1, left) and night-time (four to seven hours after sunset UTC+1, right) per local climate zone (LCZ) for Netatmo CWS and reference stations in August 2015. Each distribution consists of mean values per station and time period in the respective LCZ. The number of sites per LCZ (CWS= n , reference= ref) is written below the top horizontal axis. (Figure reproduced from Fenner et al. 2017; modified)

investigate with most urban meteorological networks when only one or few sites are located within the same structural environments. Intra-LCZ variability of T in Berlin is especially pronounced during the summer months. The inter-quartile range can reach up to 2.0 K and the maximum range even up to 6.6 K during daytime (Figure 3, left). Night-time hours typically show higher intra-LCZ variability of T than during daytime; the month August 2015 was an exception to that (Figure 3). Furthermore, LCZ classes with a higher number of CWS also exhibit larger intra-LCZ variability of T .

Inter-LCZ differences have been analysed with CWS data, including statistical significance tests due to the large number of sites (not shown here, cf. Fenner et al. 2017). Inter-LCZ T differences are high during nights, conforming to the notion that local-scale differences and urban heat islands are typically pronounced at night-time (Stewart and Oke 2012). Structurally dissimilar LCZ classes such as LCZ 2 (compact midrise) and LCZ D (low plants) show highest differences, though inner-city ‘urban’ LCZ also differ in their T regime. Most of these inter-LCZ differences are statistically significant. It is thus possible to differentiate urban environments by their T regime by crowdsourced data from CWS.

Conclusions and outlook

Ongoing increase of CWS density and public data sharing improves the data basis for exploration of urban climates and atmospheric processes. However, the vast amount of crowdsourced data requires new methods to exploit the full potential, especially concerning data QA. Our QA procedure enables assessment and filtering of CWS data from Netatmo stations for entire urban regions, targeting errors that are typically associated with this novel data set. The filtered data set for Berlin pro-

vides information with deviations to reference data that are often within the sensors’ accuracy. This allows utilising CWS data for investigating urban thermal climates. T differences between local-scale environments obtained through CWS data are in line with results obtained with high-quality reference networks. Moreover, intra-LCZ variability can be assessed with CWS data, which is difficult if only few measurement sites are available. Since the annual cycle of T observed by CWS and reference stations is comparable, we conclude that CWS yield reliable information not only during short periods but also for long-term observations. Nonetheless, care must be taken when investigating data from few or single CWS, as most Netatmo CWS are not installed following standards for meteorological observations in cities. Results from individual CWS are difficult to interpret if it is unknown where and how exactly the station is set up. However, considering data from a large ‘crowd’, spatio-temporal mean values provide reliable information, but individual CWS values might deviate strongly from a reference station. This highlights the need for further research to understand how measurements obtained from CWS can be combined with existing meteorological networks. In this respect, detailed meta data are crucial, which is a key issue with crowdsourced CWS data, but also for reference networks (Stewart 2011). Reference networks are indispensable in order to cover areas like urban parks where only few or even no CWS are present, and to evaluate the quality of CWS measurements. Future research utilising crowdsourced atmospheric data could therefore focus on the question of how issues concerning missing meta data of CWS could be overcome or could investigate spatio-temporal characteristics of atmospheric humidity, wind, and precipitation, which are also measured by CWS.

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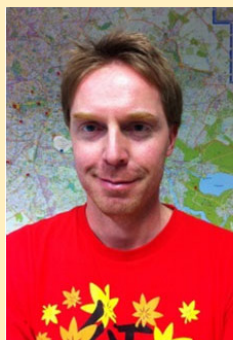
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Urban Areas and Global Change sessions at the American Geophysical Union Fall Meeting in New Orleans, USA

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and

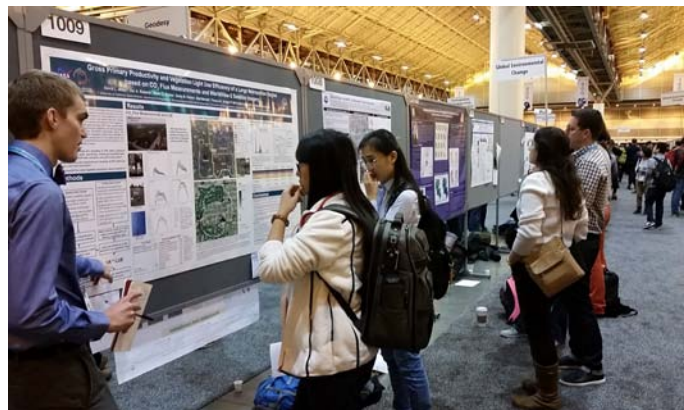
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The 2017 Fall Meeting of the American Geophysical Union (AGU) was held in New Orleans, Louisiana, USA from December 11–15, 2017, and featured more than 22,000 talks and poster presentations by Earth and space science researchers from around the world. Among the many areas of research present, the meeting featured a very well-attended Urban Areas and Global Change session convened by Prof. **Galina Churkina** (Yale University, USA), Prof. **Joe McFadden** (University of California, Santa Barbara, USA), Dr. **Patricia Romero-Lankao** (National Center for Atmospheric Research, USA), and Dr. **Tim Butler** (Institute for Advanced Sustainability Studies, Potsdam, Germany). The session, consisting of three full oral sessions as well as a poster session, showcased the diversity of research devoted to urban atmospheric, land cover, and ecological processes.

The session convened on the first day of the meeting, with the first oral session focusing on heat stress, including extreme heat events and future climate scenarios. Invited speaker Dr. **Scott Krayenhoff** (Arizona State University, USA) presented his talk “*Climates of U.S. cities in the 21st century*,” which featured research into variations in the urban heat island across different development densities and climate zones in the United States. Key results included the finding that increasing tree cover can reduce daytime more than nighttime temperatures, and that the urban heat island has a stronger link to urban expansion in eastern U.S. cities than elsewhere. Spatial characterization and magnitude of the urban heat island was discussed in case studies of Brisbane, Australia (**Sarah Chapman**, The University of Queensland), New York, USA (Prof. **Prathap Ramamurthy**, City College of New York, and Dr. **Luis Ortiz**, City College of New York), and Chicago, USA (Prof. **Ashish Sharma**, University of Notre Dame).

The second oral session featured methods for quantifying the effects of urban vegetation cover and water use on urban temperatures. These talks featured both remote sensing and climate modeling investigations, focusing on urbanized areas in the U.S., Colombia, Japan, as well as global urban comparisons. Dr. **Keigo Matsuda**

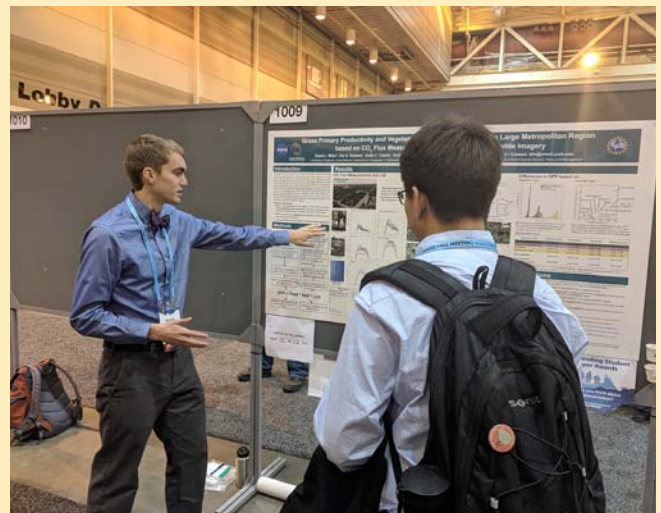
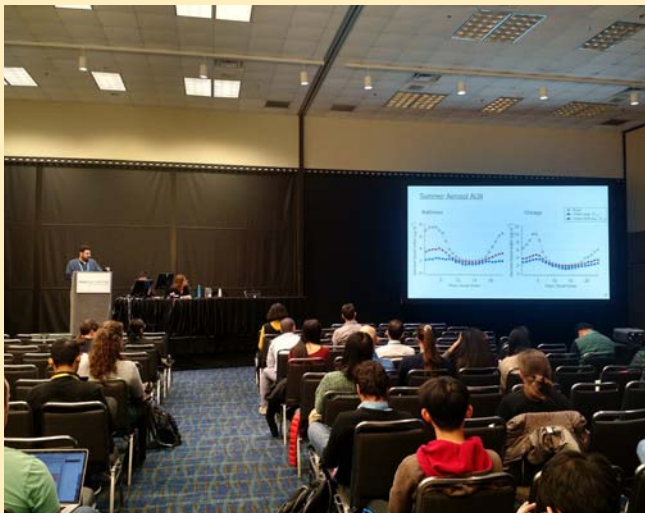


The AGU Fall Meeting in New Orleans featured over 22,000 oral and poster presentations by Earth and space science researchers from around the world, and reflected the growing importance of urban areas in a changing global climate.

(Japan Agency for Marine-Earth Science and Technology) demonstrated very high resolution, three-dimensional modeling of urban heat, vegetation, and air flow. Dr. **Pouya Vahmani** (Lawrence Berkeley National Laboratory, USA) used a satellite-supported WRF model to assess relationships between urban heat, cool roofs, impervious surface fraction, and irrigation. Dr. **Lei Zhao** (Princeton University, USA) used CESM simulations to evaluate the effects of heat waves in urban environments. **Erin Wetherley** (University of California, Santa Barbara, USA) investigated sub-scale vegetation temperatures in the Los Angeles metropolitan region using airborne hyperspectral and thermal remote sensing imagery.

The third and final oral session focused on the urban heat island in several regions, assessing its magnitude, geographic variability, and effects on air quality. **Tirthankar Chakraborty** (Yale University, USA) used MODIS land surface temperatures to quantify seasonal and interannual changes in the urban heat island across various climate zones and cities. Prof. **George Ban-Weiss** (University of Southern California, USA) modeled how cool roofs affect the production of urban ozone and pollutant dispersal compared to standard roofing materials. Other members of the Ban-Weiss lab presented research on cool walls and air quality (**Jiachen Zhang**, University of Southern California, USA) and air temperature and land use (**Mohammadhassan Mohegh**, University of Southern California, USA).

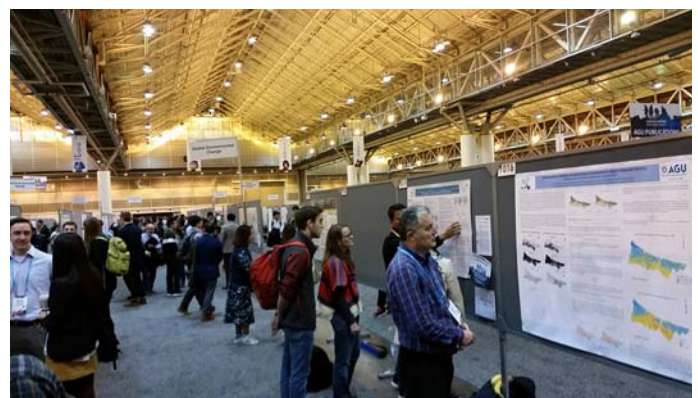
The poster session was held on the morning of the second day of the meeting, and was well attended by a broad range of the AGU community. The session fea-



Presenters at AGU included Anna Scott (Johns Hopkins University, USA, top left), Kangning Huang (Yale University, USA, top right), Michael Battaglia Jr (University of Maryland Baltimore County, USA, bottom left), and David Miller (University of California Santa Barbara, USA, bottom right).

tured research from all corners of the globe, including Japan, China, United States, Turkey, India, South Korea, and Indonesia. Projects featured both well-established and cutting-edge techniques for quantitatively studying urban form and function, including remote sensing, modeling and simulation, micrometeorology networks, flux towers, and in situ investigations. This body of work examined diverse urban environments, ranging from a small town in Texas, USA, to the megacities of Jakarta and Beijing, as well as several comparisons between cities across the country and across the globe. Physical sciences were well represented, featuring investigations into urban surface energy and carbon fluxes, urban carbon deposition, urban heat island variability and mapping, city structure, and future climate projections under varying climate and urban development scenarios. Social science posters featured research into the links between urbanization and mobility, agriculture, thermal comfort, local climate zones, and urban lighting.

The Urban Areas and Global Change sessions at the [2017 AGU Fall Meeting](#) followed successful sessions of the same name over the past several years. The organizers indicated that they hope to continue this tradition at the [2018 AGU Fall Meeting](#), and they welcome the continued participation by members of the international urban climate community.



International Conference on Urban Comfort and Environmental Quality (URBAN-CEQ) in Genoa, Italy

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The International Conference on Urban Comfort and Environmental Quality (URBAN-CEQ), held in Genoa, Italy on 28-29 September 2017, was organized by the University of Genoa Architecture and Design Department (DAD) and Department of Civil, Chemical and Environmental Engineering (DICCA) (<http://scienzearch.unige.it/URBAN-CEQ-INFORMATIONS>). The conference focused on the evaluation of environmental quality in urban areas, considering a wide range of environmental problems, such as thermal comfort and air quality, and their effects on citizen life conditions and health. The event brought together participants from nine countries – including specialists in fluid dynamics, urban environmental quality, climate and human thermal comfort, as well as designers and managers of urban areas – in order to share activities on these topics and identify further developments and key issues to be addressed for the improvement of urban environmental quality (Fig. 1).

More than two thirds of European citizens live in cities, where many environmental problems are concentrated – such as thermal discomfort and poor air quality, which can even be responsible for life-threatening conditions. Thus it is more and more urgent that urban regeneration strategies be linked to objectives of environmental quality improvement. Prof. **Thomas Auer** (Technische Universität München) presented a keynote lecture on mitigation and adaption strategies for the holistic design of a fully de-carbonized built environment, and Prof. **Bert Blocken** (Eindhoven University of Technology in the Netherlands) gave another keynote lecture on key aspects of CFD simulation of urban microclimate. During the two-day conference, 25 speakers presented their work and their future perspectives on the topics addressed by the conference (Fig. 2).

During the conference, the “Micro-Clima” workshop was organized by DAD, the Technische Universität München and the Chinese University of Hong Kong. The aim was to investigate the relationship between microclimatic conditions and people’s behaviour in an urban context. The workshop was divided into two components: a field measurement exercise in which participants collected data along a path in the city centre of Genoa



Figure 1. URBAN-CEQ opening session.

during both day and night, and a session for data presentation and discussion. Around 15 attendees participated in the field exercise, and along the path they were subjected to different climatic and physical stress conditions (Fig. 3). The group stopped at seven fixed points to make measurements: micro-climate data were collected by means of a portable weather station equipped with a globe thermometer, skin temperature was recorded by infrared thermocamera (Fig. 4), and thermal comfort was self-assessed by participants by filling in a form through an app. On the second day the collected data were presented and discussed, using visualization techniques and tools.

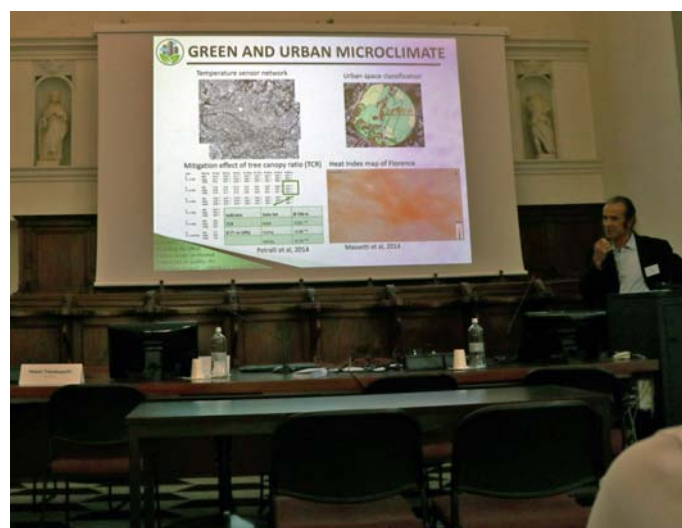


Figure 2. Presentation of the SMARTUrban project..



Figure 3. Micro-Clima workshop: route and stopping points of the thermal comfort measurement campaign.

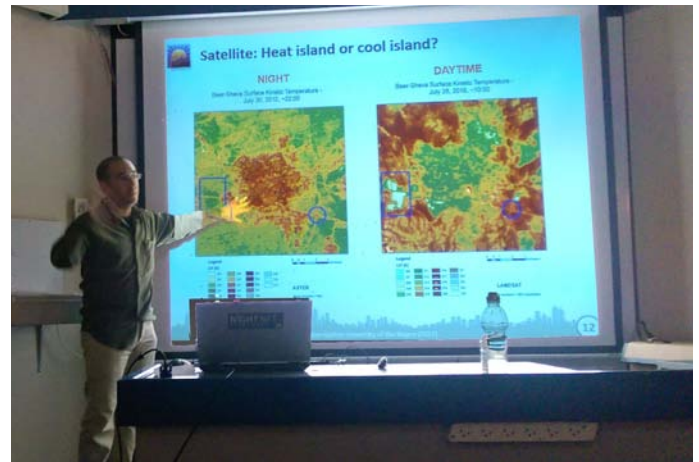


Figure 4. Measurements by portable weather station with globe thermometer, and infrared thermocamera.

Research on urban form and climate presented at DDD in Israel

Understanding the ways that urban design can modify the local climate within a city is an crucial ongoing challenge, and one which takes on special significance when conditions are hot and arid. The urbanized population of dryland regions is growing rapidly, and many desert cities are facing the combined risk of extreme heat stress and scarce water resources – both of which may be exacerbated by local and global climate change.

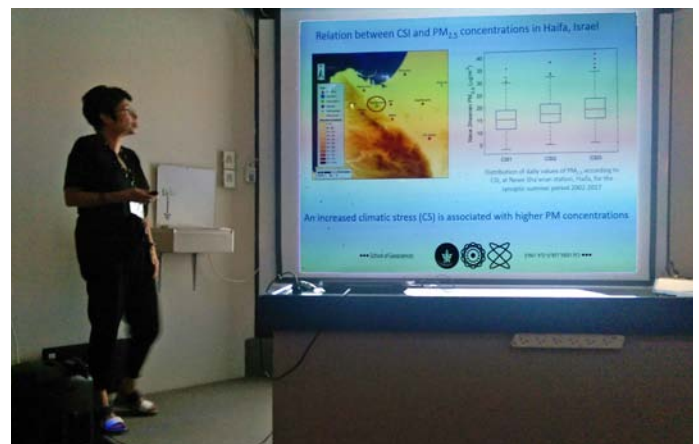
Tackling these issues was the theme of a session entitled “Urban form of dryland cities - mitigating the effects of climate change and environmental degradation,” held at the [Sixth International Conference on Drylands, Deserts and Desertification \(DDD\)](#) on November 6-9 at the Jacob Blaustein Institutes for Desert Research (BIDR) of Ben-Gurion University of the Negev in Israel. The session was organized and chaired by **Evyatar Erell** from BIDR, and included presentations by researchers from both Israel and abroad.



BIDR post-doctoral fellow **Shai Kaplan** presented his work on the mapping of intra-urban microclimate variability, comparing results from ground-based surface measurements, remotely-sensed satellite data, and simulation modeling. He showed that the use and interpretation of data from different approaches could lead to significantly different conclusions regarding both the magnitude and timing of the urban heat island.



The first invited speaker was former IAUC President **Gerald Mills**, from the School of Geography at University College Dublin. Gerald surveyed the progress that has been made in the field of urban climatology over the last several decades, diagnosing its current status and looking ahead to its future prospects. He emphasized that while remarkable advances have been made in the modeling of climatic processes in cities, there is still a shortage of actual data to fuel these increasingly sophisticated models. Introducing the [WUDAPT](#) framework for describing the structure of world cities, he tracked the progress that has already been made in the basic mapping (Level 0) of a range of cities and pointed the way toward a more detailed description of urban terrain (Levels 1 and 2) based on the adoption of international building typologies and collection of crowd-sourced data.



The final presentation was made by **Hadas Saaroni** of the Department of Geography at Tel Aviv University, on the development and application of a new Climatic Stress Index – particularly as a tool for synoptic classification of summer season weather conditions. An improved model for predicting climatic stress and particulate concentrations in the urban atmosphere, this index makes use of synoptic classifications based on an “environment-to-climate” paradigm rather than vice-versa.

The [DDD Conference](#) has emerged as an important global gathering of scientists, practitioners, and decision-makers from over 60 countries around the world who are concerned about living conditions in dryland regions – and about how, in practice as well as in theory, these conditions may be improved through sustainable development. – *David Pearlmutter, UCN Editor*

Recent Urban Climate Publications

Ahmad NH, Inagaki A, Kanda M (2017) Large-Eddy Simulation of the Gust Index in an Urban Area Using the Lattice Boltzmann Method. *Boundary-layer Meteorology* 163:447–467.

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In this edition is a list of publications that have come out between **September and November 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. 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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<http://www.arch.kmitl.ac.th/auc2018aura/>

CITIES AND CLIMATE CHANGE SCIENCE CONFERENCE (CITIES IPCC)

Edmonton, Canada • March 5-7, 2018

<https://www.citiesipcc.org/>

EUROPEAN GEOSCIENCES UNION GENERAL ASSEMBLY

Vienna, Austria • April 8-13, 2018

<https://www.egu2018.eu/>

AMERICAN ASSOCIATION OF GEOGRAPHERS (AAG) ANNUAL MEETING

New Orleans, Louisiana • USA, April 10-14, 2018

<http://annualmeeting.aag.org/>

RESILIENT CITIES 2018, THE 9TH GLOBAL FORUM ON URBAN RESILIENCE AND ADAPTATION

Bonn, Germany • April 26-28, 2018

<https://resilientcities2018.iclei.org>

10TH INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC10) AND 14TH SYMPOSIUM ON THE URBAN ENVIRONMENT (SUE) OF THE AMERICAN METEOROLOGICAL SOCIETY (AMS)

New York, USA • August 6-10, 2018

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

WORLD FORUM ON URBAN FORESTS: CHANGING THE NATURE OF CITIES

Mantua, Italy • November 28 - December 1, 2018

<https://www.wfuf2018.com/>

PASSIVE LOW ENERGY ARCHITECTURE (PLEA 2018)

Hong Kong, China • December 10-12, 2018

<http://www.plea2018.org/>

Joint Erasmus+ Masters on sustainable urban climate change management

Sustainable management of urban climate change is a vital need of the 21st Century and new professionals to lead this process are urgently needed.

Glasgow Caledonian University (GCU), UK; Lahti University of Applied Sciences (LAMK), Finland and University of Huelva (UHU), Spain along with 13 Associate Partners have obtained European Union funding under its Erasmus+ Programme to offer an *Erasmus Mundus Joint Master's Degree* titled, *Master of Urban Climate and Sustainability (MURCS)*. The programme aims to produce high calibre graduates with skills and knowledge to understand, assess and manage climate resilience in cities.

The two-year programme, based on a jointly developed curriculum by GCU, LAMK and UHU, will lead to triple degrees – MSc in Sustainable Urban Environment (GCU), MEng Environmental Technology (Urban Sustainability) (LAMK) and MSc Environmental Technology (UHU).

The funding will allow the programme to target both existing urban professionals, as well as those with multidisciplinary environmental backgrounds, to create professional pathways in leading sustainable urban climate change management. Graduates will gain critical understanding of the complexity of urban sustainability and the need for local action to combat climate change. They will develop intellectual and practical skills as well as the ability to use

tools for the collection, analysis and interpretation of data related to urban climate change and sustainability.

18-20 fully funded studentships will be offered (covering tuition fee, monthly stipend, travel and relocation costs). All students will begin their education in Glasgow in Semester 1 before spending their second semester in Finland. As the modules become more specialised, the third semester will see them based at one of the three partner Universities relevant to their specialism. They will then undertake a thesis project, jointly supervised by two academics from different partner institutions in Semester 4.

More information, eligibility requirements and selection criteria at: www.murcs.eu

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10th International Conference on Urban Climate (ICUC10)

*August 6-10, 2018
New York City, USA*



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

We would like to inform you that the deadline for the submission of abstracts for the **10th International Conference on Urban Climate/14th Symposium on the Urban Environment (ICUC10)** has been extended to **January 2, 2018**. The conference will be held in New York City, **6 – 10 August 2018**. ICUC10 is organized jointly by IAUC and the American Meteorological Society (AMS), and sponsored by the World Meteorological Organization, and the US National Science Foundation.

The theme of the Conference is **Sustainable and Resilient Urban Environments**. 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. We welcome contributions in this topic and in any other topic that relates to Urban Climate.

There is NO FEE to submit an abstract! Detailed information, call for papers and link to the abstract submission portal are all available on the [conference webpage](#).

Note to students from developing countries: We have secured financial assistance for limited travel support for students from developing countries in need of travel assistance. We encourage these students to submit their abstracts and request travel assistance in the abstract submission form. Travel awards will be granted after the abstract acceptance time.

Note to colleagues from countries banned from entering US: We encourage citizens from countries currently banned from entering the US to also submit an Abstract before the deadline. The Organizers are working to accommodate their research into the conference.

For further information feel free to contact the Local Organizers, Profs. Jorge E. González and Prathap Ramamurthy of the City College of New York, at icuc10@icuc10.org

Conference Link:

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

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/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/land use for urbanization
- Mitigation & adaptation strategies for climate changes
- Climate information services for cities

Studies of urban climate and processes

- Boundary layer and canopy layer urban heat islands
- 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

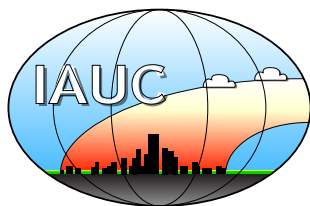
Urban design and planning with climate

- 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.



IAUC Board Members & Terms

- Gerald Mills (UCD, Dublin, Ireland): 2007-2011; President, 2009-2013; Past President, 2014-2018 (nv)
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- Aya Hagishima (Kyushu University, Japan): 2015-2019
- Jorge Gonzales (CUNY, USA): ICUC-10 Local Organizer, 2016-2021
- Dev Niyogi (Purdue University, USA): ICUC-10 Local Organizer, 2016-2021
- R. Leena Jarvi (University of Helsinki, Finland): 2016-2020
- Ariane Middel (Arizona State University, USA): 2016-2020

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nv = non-voting

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The next edition of *Urban Climate News* will appear in late March. Contributions for the upcoming issue are welcome, and should be submitted by February 28, 2018 to the relevant editor.

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

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