Urban Climate News

Quarterly Newsletter of the IAUC

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From the IAUC President

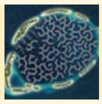
Happy New Year to all of the IAUC community. As we enter 2022 many health officials from around the world, including the Secretary-General of WHO, are saying that the COVID-19 pandemic will end this year, because of the widespread use of vaccines and the developing dominance of the Omicron variant that will help develop general global immunity. Let us all hope that they are right, because both personally and professionally, we are desperate to return to a sense of normalcy in our lives. As has been the case for most of us, for me it has been two years without any face-to-face international meetings. Perhaps somewhat optimistically I have a couple of GCOS/WMO meetings to attend in Ireland and Brazil in March…… we shall see!

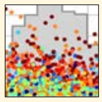
The Board and Executive of IAUC are keen to maintain activity within our energetic and diverse community – our highly successful online seminar series will kick off for 2022 early in the New Year, and we remind our members that organisation of the August 2022 IAUC Virtual Poster Conference is continuing apace with the assistance of funds provided from IAUC reserves. This low-fee conference focused on our graduate and early career researchers will feature daily keynotes, a multiple time-zone friendly format, and with various other innovations that will provide significant points of difference from other virtual conferences. Remember that this is a stepping-stone to our flagship ICUC-11 conference to be held in 2023.

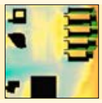
I also want to remind all our members that there **is only one ICUC conference**, and that is the one to be held in **Sydney in August 2023**. You may or may not be aware that there is a fake conference organiser trading on our hard-earned conference name that is organising bogus ICUC conferences, as well as other bogus conferences purporting to be associated with other professional associations like IAUC. Please do not accidentally register with one of those. All genuine ICUC meetings will be well-publicised on our IAUC website and in our Newsletter and email list.

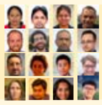
I hope that you enjoy this current Newsletter that is well up to the usual standard of excellent

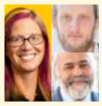
Inside the December issue...











articles and reports. Note the *Special Report* on the very useful new book – **"The Urban Heat Island: A Guidebook" by Iain Stewart and Gerald Mills**. I am pleased to advise that the authors and publisher (Elsevier) have very kindly agreed to make available an IAUC version of this book in the Teaching Resources section of our website at urban-climate.org. This will be a hugely valuable resource, especially for our younger members, and will become available shortly. We thank them sincerely.

On a highly positive note, I am delighted to announce that the IAUC Board has approved a **new IAUC Executive** that from August 2022 will take over from me, Andreas Christen and Ariane Middel as President, Secretary, and Treasurer of the IAUC respectively. *(continued on page 40...)*

– Nigel Tapper,
IAUC President
nigel.tapper@monash.edu

2021's weather disasters brought home the reality of climate change

Heat waves. Floods. Megadroughts. This year's weather showed us that climate change is here—and deadly.

December 2021 — From punishing heat in North America to record-breaking floods in Europe and Asia, this year's weather showed us what it looks like to live in a world that has warmed by 2 degrees Fahrenheit (1.1 degrees Celsius) over the past century.

"Dangerous climate change is already here. That's a harsh reality we need to recognize," says Michael Wehner, an extreme weather researcher at the Lawrence Berkeley National Laboratory.

Extreme weather is already taking homes, businesses, and lives. Canada's recent floods may be the most expensive in the country's history, potentially costing an estimated $7.5 billion. The 18 weather disasters that hit the United States in 2021 together cost more than $100 billion, according to the most recent estimates.

In August, Wehner and other scientists on the Intergovernmental Panel on Climate Change published a report indicating they were now more confident than ever that climate change is influencing the world's worst weather events, including these five.

Pacific Northwest heatwave

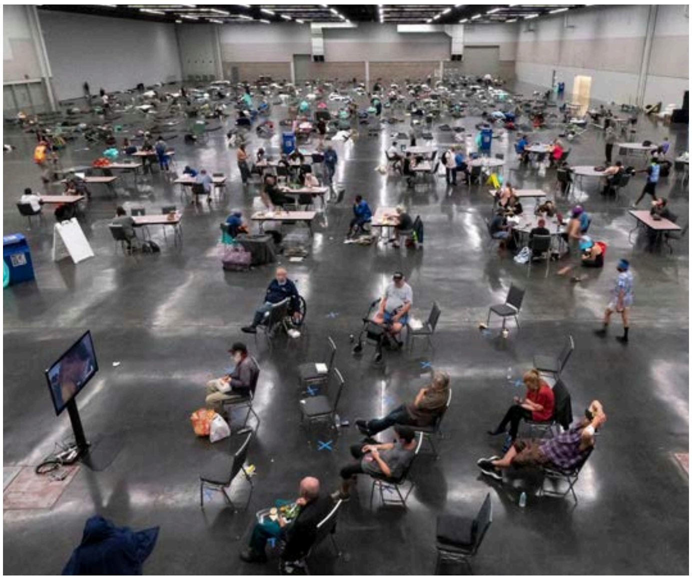
The Pacific Northwest and southwestern Canada—a region that supports some 13 million people is known for rainy, mild weather—experienced deadly heat this summer. Major cities such as Portland, Seattle, and Vancouver, where many residents lack air conditioning, saw historically high temperatures that surpassed 100°F (38°C). The intense heat resulted from a weather phenomenon called a heat dome, in which an area of high pressure acts like a lid on a pot and keeps heat trapped over a specific region.

Research on the heatwave found that its intensity would have been "virtually impossible" without the planet-warming greenhouse gases that have been emitted into the atmosphere over the past 120 years. As a result of the heat, hundreds of people died in the region. One study published this summer concluded that more than a third of all heat-related deaths worldwide could be blamed on climate change. And it's those already suffering the most—from lower incomes, poor health, or old age—who are most harmed by heat.

Plants and animals struggle to cope with extreme heat, too. In the Pacific Northwest, millions of marine animals died, as did many on land. Farmers saw berries roast on their vines.

Megadrought in the West

In August, the U.S. declared a water shortage on the Colorado River—a first for the waterway. Lake Mead, one of the river's most important reservoirs, dropped to historically low levels. While the declaration triggered water cuts to farmers in Arizona and parts of Nevada, with some 40 million people at least partially dependent on the river for water, future droughts could prompt more widespread water reductions.



On June 27, Portland residents fill the Oregon Convention Center, which became a temporary cooling center when a record-breaking heat wave struck the Pacific Northwest. In regions unaccustomed to intense heat, many homes lack air conditioning, leaving those inside vulnerable to heat-related illnesses. *Source:* nationalgeographic.com

A "megadrought" has been gripping the West since 2000. While the region would have likely experienced drought regardless of human influence, scientists say climate change is making it worse than it's been in over 1,000 years.

Drought can create dangerous feedback loops. As the air warms, it sucks more moisture out of rivers, lakes, plants, and even the soil, which can in turn make the ground even hotter and drier.

And while the drought in the western U.S. was historic, climate change is likely to worsen drought around the world, with historically arid regions in Africa and the Middle East hit hardest.

Western wildfires

This year, California's Dixie fire was the second largest in the state's history. It burned half a million acres and some 400 homes, contributing to a string of busy fire seasons that have plagued the West. North America wasn't alone. Large wildfires broke out in Turkey, Greece—and perhaps

On August 29, a group of people walk through New Orleans' French District during Hurricane Ida. The Category 4 storm struck with winds of 150 mph. It was the strongest storm to hit Louisiana since the 1850s, and it caused widespread destruction as it moved east, eventually flooding New York City. *Source:* nationalgeographic.com

most surprisingly—Siberian Russia.

When extreme heat and drought coincide, zapping the soil's moisture and creating fields of dry vegetation, it only takes a small spark to ignite a deadly blaze. As climate change worsens heat and drought, it creates the conditions for larger and more frequent fires. In some parts of the West fire season now lasts all year.

Not only did the year's wildfires immediately threaten homes and businesses, they also produced unhealthy air pollution and threatened endangered species, including California's famed sequoia trees.

Extreme floods… everywhere

Canada, the U.S., Germany, China—extreme rainfall and the floods they triggered plagued the globe this year. In each of these places, the volume of precipitation was historic.

In British Columbia, 20 towns set rainfall records; Nashville saw its fourth wettest day ever; more rain fell on Central Park in a single hour than ever before in that timespan; German towns were inundated with more rain in two days than in a normal month; one day of rain in Zhengzhou, China, exceeded a year's worth of average annual precipitation.

More intense rainstorms result from warming temperatures; for every 1.8°F (1°C) rise, the atmosphere can hold 7 percent more moisture. With more water at their disposal, storms have the potential to dump enough rain to cause flooding.

Many of this year's floods brought to light how population centers and transit routes were engineered for a climate that may not prevail for much longer. For example, goods going to and from Asia stalled at Vancouver's port, waylaid by floods. In major cities, underground train tunnels were swamped and streets turned into rivers.

Hurricane Ida: New Orleans to New York

Extreme rain is one major way climate change is making hurricanes worse. Hurricane Harvey, which struck Houston in 2017, was one of the most extreme examples of this. The storm dumped 60 inches of rain in some parts of Texas.

But it was Hurricane Ida that exemplified another dangerous trait of climate change-charged hurricanes: rapid intensification. This occurs when a hurricane's winds increase by at least 35 mph in under 24 hours. Ida far surpassed that rate, growing by about 60 miles per hour in a day, from a Category 1 storm to a Category 4, its top winds clocking at 150 mph.

While Ida moved relatively quickly, scientists expect that future hurricanes on average will move more slowly over land, dumping more rain on a location and causing extreme flooding. Hurricane Harvey did just that over Houston; in 2020, Hurricane Sally stalled over Alabama. Researchers anticipate that future intense, rainy, sluggish storms will cause more destruction; as sea levels continue rising, deadly storm surges brought by hurricanes will worsen, too.

Only the beginning

Scientists are still researching how climate change will influence winter weather, and they're becoming increasingly confident that Arctic warming is producing harsher winter storms.

One recently published study found a possible link between the September Texas freeze and climate change, suggesting that the barrier between cold Arctic air and warm tropical air is becoming more unstable and that the polar vortex—the flow of air moving through the stratosphere—is becoming increasingly likely to deliver intense winter storms.

As the world's weather becomes more tumultuous, the public may be starting to perceive climate change differently.

A recent update of a national survey found that 70 percent of Americans surveyed thought climate change was influencing the weather. In the poll's 14-year history, climate change belief was the highest it's ever been: 76 percent of Americans surveyed believed it was happening and 52 percent thought they were being personally affected by it.

Temperatures will continue to rise, and so extreme weather could continue to shape climate change beliefs, emails one of the survey's authors, Edward Maibach, an expert on climate change communication at George Mason University.

"The hard truth is that most American communities will almost certainly experience more and worse climatic events in the decades to come," he says. *Source:* https://www.nationalgeographic.com/environment/article/this-year-extreme-weather-brought-home-reality-of-climate-change

Europe’s urban population remains at risk due to levels of air pollution known to damage human health

The vast majority of Europe’s urban population is exposed to levels of air pollutants above new World Health Organization (WHO) guidelines, according to an updated European Environment Agency (EEA) analysis on ambient air quality in Europe

December 2021 — The EEA ‘Air quality in Europe 2021’ report updates and expands on an earlier assessment of the status of air quality by comparing pollutant concentrations in ambient air across Europe against the new WHO air quality guidelines published in September 2021. It finds that the majority of Europeans are exposed to levels of air pollutants known to damage health.

- In the 27 Member States of the European Union (EU), 97% of the urban population is exposed to levels of fine particulate matter above the WHO guideline. Levels of **particulate matter** are driven by emissions from energy use, road transport, industry and agriculture.
- Regarding **nitrogen dioxide**, 94% of the urban population is exposed to levels above the WHO guideline, due predominantly to emissions from road transport.
- 99% of the urban population is exposed to levels of **ozone** above the WHO guideline, linked to emissions of nitrogen oxides and volatile organic compounds, including methane, and high temperatures associated with climate change.

The report finds that **human activities** are the key driver behind the dangerous levels of particulate matter, nitrogen dioxide and ozone in urban air. Overall emissions of all **key air pollutants** across the EU **declined in 2019**, maintaining the trend seen since 2005. Nevertheless, delivering clean and safe air for Europe will require ongoing and additional reductions in emissions. Looking ahead, the report says **more action is required** by all Member States if they are to meet future emission reduction commitments under the EU’s National Emissions reduction Commitments Directive (NEC Directive).

The EU has also set standards for key air pollutants in the EU’s Ambient Air Quality Directives. Under the European Green Deal’s Zero Pollution Action Plan, the European Commission set the **2030 goal of reducing the number of premature deaths** caused by PM2.5 by at least 55% compared with 2005 levels.

To this end, the European Commission initiated a revision of the Ambient Air Quality Directives, which includes a **revision of EU air quality standards** to align them more closely with WHO recommendations. Citizens and stakeholders are invited to express their views through a public consultation run by the European Commission until 16 December 2021.

In 2019, air pollution continued to drive a significant burden of premature death and disease in Europe. In the EU, **307,000 premature deaths** were linked to exposure to fine particulate matter in 2019, a decrease of 33% on 2005. *Source:* https://www.eea.europa.eu/highlights/europes-urban-population-remains-at

How the Building Industry Blocked Better Tornado Safeguards

Engineers know how to protect people from tornadoes like the ones that recently devastated parts of Kentucky, but builders have headed off efforts to toughen standards.

December 2021 — After a tornado killed 162 people in Joplin, Mo., safety experts and cement manufacturers proposed a way to save lives: Require most new apartments, commercial structures and other large buildings in tornado-prone areas to have safe rooms — concrete boxes where people can shelter, even if the building around them is torn to shreds.

Safe rooms provide "near-absolute protection" during a tornado, according to the Federal Emergency Management Agency. They can cost as little as $15,000 for a small shelter in a commercial building, and possibly could have saved the six workers who died when a tornado destroyed the Amazon warehouse in Edwardsville, Ill., two weeks ago.

But the 2012 proposal was blocked by a little-known organization that sets the building codes widely used by states and cities around the country. That group, the International Code Council, is made up of state and local code officials from around the country. Before it could vote, the proposal was scrapped by a council committee made up of building industry representatives and local code officials. The committee found the 2012 safe room proposal to be "overly restrictive and contained several technical flaws."

While experts say the technology and design standards exist to better protect people and buildings from tornadoes, attempts to incorporate those designs into building codes have repeatedly been blocked or curtailed by the building industry, according to public documents and people involved in efforts to tighten the model codes.

"It really does kind of boil down to money," said Jason Thompson, vice president of engineering at the National Concrete Masonry Association and one of the proponents of the 2012 change. "There's just different groups out there that want to keep the cost of construction as low as possible."

The stakes are growing. Tornadoes, long associated with Oklahoma, Kansas and other sparsely populated Plains states, appear to be shifting eastward, occurring more frequently in states like Kentucky and Tennessee, according to Victor Gensini, a professor in the department of geographic and atmospheric sciences at Northern Illinois University.

Although scientists lack the data to clearly connect tornadoes with climate change, a warming planet is producing more humid air near the Earth's surface, which may in turn be fueling more tornadoes, he said. And it's putting more people at risk. "The population density as you go east of the Mississippi River increases exponentially," Dr. Gensini said.

'It's totally inappropriate'

Building codes are a state responsibility in the United States. And, rather than each state devising its own building codes from scratch, the International Code Council issues a series of model codes for residential and commercial building, plumbing, electrical and even wildfire safety. States can then adopt those codes, modifying as needed.

Clearing debris at the Amazon warehouse in Illinois, that was torn apart by a tornado this month. *Source:* nytimes.com

As engineering science improves, the council's model codes are updated every three years. Proposed changes need to be approved by council members. But before those proposals get a vote, they must first be endorsed by committees that include industry representatives. That step is designed to weed out ideas that experts feel are poorly thought out or hard to implement. The process is designed to ensure that only changes with broad consensus will advance.

But it also gives industry an opportunity to block changes that could increase their costs. Adding a safe room can cost from $7,000 for a house to as much as $100,000 for a version that holds about 100 people in a commercial building, according to Jim Bell, director of operations for the National Storm Shelter Association.

The 2012 safe room proposal was introduced by the Insurance Institute for Business & Home Safety, a research group backed by the insurance industry that studies changes in building construction that can reduce damage during storms, fires and other disasters, then lobbies for the adoption of those changes. It was joined by trade groups for the cement industry, whose members stood to benefit from increased demand for safe rooms.

But at a hearing before the committee that would decide whether the proposal would advance to a vote by the council, representatives of the building industry lined up to oppose it, according to a video recording of the hearing. "It's totally inappropriate," said Ron Burton, who at the time worked for the Building Owners and Managers Association and had previously overseen codes and standards at the National Association of Home Builders.

"I'm concerned that this is just not the fix," said Jonathan Humble, a director of construction codes and standards at the American Iron and Steel Institute. "It's way too soon to do a knee-jerk reaction," said Chad Beebe, an official with the American Hospital Association. The committee voted down the proposal. It approved a narrower requirement for safe rooms in most new schools, as well as emergency facilities like police stations and 911 call centers.

Craig Fugate, the FEMA administrator at the time, called the code-development process a perennial debate between safety advocates pushing better design in the face of disasters, and developers who want less red tape. "There's a lot of building codes in this country that are based on hope: We just hope it won't be that bad," Mr. Fugate said. "And people die."

The power to stop code changes

The idea of requiring safe rooms more widely got a boost in 2014, when the National Institute of Standards and Technology, an office within the Department of Commerce, issued a report on the 2011 Joplin tornado. It recommended installing tornado shelters in new and existing multifamily residential buildings, commercial buildings, schools and other buildings in high-risk areas.

The national institute initially planned to push for that recommendation to be incorporated into the model building codes, according to Marc Levitan, a tornado researcher at the institute and the lead investigator for the Joplin report.

Those plans caught the attention of the home building industry, which wields particular clout in the process of developing codes and boasted to members one year that just six percent of the proposals it opposed made it past the committee stage.

The National Association of Home Builders has more than 140,000 members, and typically resists changes that would make homes more expensive. It had opposed the safe room requirement proposed in 2012, according to Stephen Skalko, an engineer who worked at the time for the Portland Cement Association and was one of the people who introduced the idea of requiring safe rooms.

In September 2014, the home builders association alerted its members that the national institute and FEMA wanted to try to get the council to mandate safe rooms for new and existing apartment buildings, businesses, schools and other large buildings in high risk areas for tornadoes.

Instead, the council slightly expanded the requirement for safe rooms for schools so that it applied to additions to existing buildings. "After discussions with many of the key stakeholders, it was understood that an iterative process over time would have more support and would be more likely to be successful," Dr. Levitan said by email. He declined to identify the stakeholders that had expressed concern.

A spokeswoman for the builders' association, Elizabeth Thompson, declined to comment on specific proposals. She provided a statement from Chuck Fowke, the group's chairman. "NAHB strongly supports building codes that result in safe, decent and affordable housing," Mr. Fowke said. "We continue to advocate for cost-effective, common-sense building codes that promote housing affordability and make new homes safer and more efficient."

'It's a political issue more than anything else'

Even as the push to require safe rooms for a wide range of buildings fizzled, engineers were working on an even more ambitious goal: changing the way buildings are designed and constructed in tornado zones, to survive all but the most violent storms.Designing a structure to withstand tornado winds involves two basic steps, according to Don Scott, who has helped develop tornado-resilient building standards at the American Society of Civil Engineers. First, the roof must be tightly secured to the walls, and the walls to the foundation, in order to transfer the pressure from the tornado downward to the strongest part of the building.

The Dawson Village Apartments complex in Kentucky. Many residents said that they rode out the tornado inside their bathrooms since the buildings lacked basements or storm shelters. *Source:* nytimes.com

Second, windows and other openings have to be strong enough to survive the debris, like tree limbs, that gets hurled through the air at high speeds during a tornado. If a window breaks, the wind pressure from the tornado is forced into the building, "like blowing up a balloon," Mr. Scott said. Covering windows with a special glaze can prevent them from being shattered, similar to hurricane-resistant windows in Florida, he said.

Mr. Scott and his colleagues at the civil engineering society set about turning the findings from the National Institute of Standards and Technology's Joplin report into building requirements to be incorporated into the next version of the model building code in 2024.Here too, the building industry succeeded at whittling down those aims.

Stronger design standards and impact-resistant windows work for any type of structure, Mr. Scott said. But as the engineering society began its work, Mr. Scott said he got a warning from Gary Ehrlich, the head of standards at the National Association of Home Builders: If Mr. Scott's group recommended applying those standards to homes, the recommendations would never get into the model codes. Ms. Thompson, the spokeswoman for the home builders' group, declined to make Mr. Ehrlich available for comment.

Evidence suggests that tornado-resistant building standards don't add significantly to the cost of a home. After a tornado devastated Moore, Okla., in 2013, the city imposed new regulations to reduce damage from future tornadoes. Those changes added about $3,000 to the cost of a new home, according to Elizabeth Weitman, the city's community development director. "It is well worth the money," Ms. Weitman said.

Even so, the American Society of Civil Engineering decided to be cautious. When its new tornado standards were released on Dec. 1, they applied only to a narrow group of buildings, such as hospitals, fire stations and police stations. They don't include apartment buildings, warehouses, most manufacturing plants or houses. Mr. Scott said he hoped that would happen eventually. "It's a political issue more than anything else," he said. "Many different organizations within the building code do not want to increase the cost of a home." *Source:* https://www.nytimes.com/2021/12/22/climate/tornadoes-building-codes-safety.html

Floating homes: The Dutch solution to housing shortages

- *Faced with worsening floods and a shortage of housing, the Netherlands is seeing a growing interest in floating homes.*
- *These floating communities are inspiring more ambitious Dutch-led projects in flood-prone nations as far-flung as French Polynesia and the Maldives.*
- *Amsterdam already has almost 3,000 officially registered traditional houseboats across its canals.*

Amsterdam has almost 3,000 officially registered traditional houseboats across its canals. *Source:* weforum.org

December 2021 — When a heavy storm hit in October, residents of the floating community of Schoonschip in Amsterdam had little doubt they could ride it out. They tied up their bikes and outdoor benches, checked in with neighbors to ensure everyone had enough food and water, and hunkered down as their neighborhood slid up and down its steel foundational pillars, rising along with the water and descending to its original position after the rain subsided.

"We feel safer in a storm because we are floating," said Siti Boelen, a Dutch television producer who moved into Schoonschip two years ago. "I think it's kind of strange that building on water is not a priority worldwide."

As sea levels rise and supercharged storms cause waters to swell, floating neighborhoods offer an experiment in flood defense that could allow coastal communities to better withstand climate change. In the land-scarce but densely populated Netherlands, demand for such homes is growing. And, as more people look to build on the water there, officials are working to update zoning laws to make the construction of floating homes easier."The municipality wants to expand the concept of floating because it is multifunctional use of space for housing, and because the sustainable way is the way forward," said Nienke van Renssen, an Amsterdam city councilor from the GreenLeft party.

The floating communities in the Netherlands that have emerged in the past decade have served as proof of concept for larger-scale projects now being spearheaded by Dutch engineers not just in European countries like Britain, France, and Norway, but also places as far-flung as French Polynesia and the Maldives, the Indian Ocean nation now facing an existential threat from sea level rise. There is even a proposal for floating islands in the Baltic Sea on which small cities would be built. "Instead of seeing water just as an enemy, we see it as an opportunity," says a Rotterdam city official.

A floating house can be constructed on any shoreline and is able to cope with rising seas or rain-induced floods by floating atop the water's surface. Unlike houseboats, which can easily be unmoored and relocated, floating homes are fixed to the shore, often resting on steel poles, and are usually connected to the local sewer system and power grid. They are structurally similar to houses built on land, but instead of a basement, they have a concrete hull that acts as a counterweight, allowing them to remain stable in the water. In the Netherlands, they are often prefabricated, square-shaped, three-story townhouses built offsite with conventional materials like timber, steel, and glass. For cities facing worsening floods and a shortage of buildable land, floating homes are one potential blueprint for how to expand urban housing in the age of climate change.

Koen Olthuis, who in 2003 founded Waterstudio, a Dutch architectural firm focused exclusively on floating buildings, said that the relatively low-tech nature of floating homes is potentially their biggest advantage. The homes he designs are stabilized by poles dug roughly 65 meters into the ground and outfitted with shock-absorbent materials to reduce the feeling of movement from nearby waves. The houses ascend when waters rise and descend when waters recede. But despite their apparent simplicity, Olthuis contends they have the potential to transform cities in ways not seen since the introduction of the elevator, which pushed skylines upward.

"We now have the tech, the possibility to build on water," said Olthuis, who has designed 300 floating homes, offices, schools, and health care centers. He added that he and his colleagues "don't see ourselves as architects, but as city doctors, and we see water as a medicine."

In the Netherlands, a country which is largely built on reclaimed land and a third of which remains below sea level, the idea is not so far-fetched. In Amsterdam, which has almost 3,000 officially registered traditional houseboats across its canals, hundreds of people have moved into floating homes in previously neglected neighborhoods.

Schoonschip, designed by Dutch firm Space&Matter, consists of 30 houses, half of which are duplexes, on a canal in a former manufacturing area. The neighborhood is a short ferry ride from central Amsterdam, where many of the residents work. Community members share nearly everything, including bikes, cars, and food bought from local farmers. Each building runs its own heat pump and devotes roughly a third of its roof to greenery and solar panels. Residents sell surplus power to one another and to the national grid.

"Living on water is normal for us, which is exactly the point," said Marjan de Blok, a Dutch TV director who initiated the project in 2009 by organizing the collective of architects, legal experts, engineers, and residents that worked to get the project off the ground.

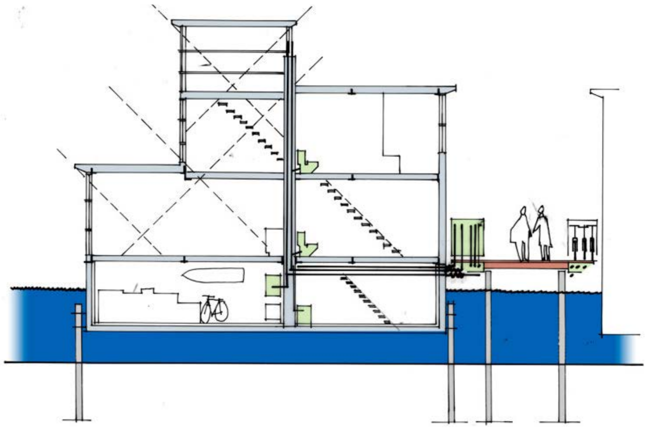
Rotterdam, which is 90 percent below sea level and the site of Europe's biggest port, is home to the world's largest floating office building, as well as a floating farm where cows are milked by robots, supplying dairy products to local grocery stores. Since the 2010 launch of the Floating Pavilion, a solar-powered meeting and event space in Rotterdam's harbor, the city has been ramping up efforts to mainstream such projects, naming floating buildings one of the pillars of its Climate Proof and Adaptation Strategy.

"Over the last 15 years, we've reinvented ourselves as a delta city," said Arnoud Molenaar, chief resilience officer with the City of Rotterdam. "Instead of seeing water just as an enemy, we see it as an opportunity." A Dutch firm is working on a proposed series of floating islands in the Baltic Sea with housing for 50,000 people.

To help protect cities against climate change, in 2006 the Dutch government undertook its "Room for the River" program, which strategically allows certain areas to flood during periods of heavy rain, a paradigm shift that seeks to embrace, rather than resist, rising water levels. Olthuis says the housing shortage in the Netherlands could fuel demand for floating homes, including in "Room for the River" areas where floods will be, at least for a portion of the year, part of the landscape. Experts say that relieving the Netherland housing shortage will require the construction of 1 million new homes over the next 10 years. Floating homes could help make up the shortage of land that is suitable for development.

Dutch firms specializing in floating buildings have been inundated with requests from developers abroad to undertake more ambitious projects. Blue21, a Dutch tech company focused on floating buildings, is currently working on a proposed series of floating islands in the Baltic Sea that would house 50,000 people and connect to a privately funded 15 billion euro underwater rail tunnel that would link Helsinki, Finland and Tallin, Estonia; the project is backed by Finnish investor and "Angry Birds" entrepreneur Peter Vesterbacka.

Waterstudio will oversee construction this winter of a floating housing development near the low-lying capital of Male in the Maldives, where 80 percent of the country sits less than one meter above sea level. It is composed of simply designed, affordable housing for 20,000 people. Underneath the hulls will be artificial coral to help support marine life. The buildings will pump cold seawater from the deep to power air conditioning systems.



A cross section of a floating house. *Source:* weforum.org

"There's no longer this idea of a crazy magician building a floating house," Olthuis said. "Now we're creating blue cities, seeing water as a tool."

Floating homes pose numerous challenges, however. Severe wind and rainstorms, or even the passing of large cruise ships, can make the buildings rock. Siti Boelen, the Schoonschip resident, said that when she first moved in, stormy weather made her think twice before venturing up to her third-floor kitchen, where she felt the movement the most. "You feel it in your stomach," she said, adding that she has since gotten used to the feeling.

Floating homes also require extra infrastructure and work to connect to the electricity grid and sewer system, with special waterproof cords and pumps needed to link to municipal services on higher ground. In the case of Schoonschip in Amsterdam and the floating office building in Rotterdam, new microgrids had to be built from scratch.

Source: https://www.weforum.org/agenda/2021/12/floating-homes-netherlands-rising-sea-levels-housing/

A rendering of a floating city planned for the Maldives, which is threatened by rising seas. *Source:* weforum.org

The Hydrological Urban Heat Island


Einara Zahn [1]


James Smith [1]


Mary-Lynn Baeck [1]


Claire Welty [2]


Stanley J. Kemp [3]


Elie Bou-Zeid [1]*

[1] Department of Civil and Environmental Engineering, Princeton University, USA; [2] Department of Chemical, Biochemical and Environmental Engineering and Center for Urban Environmental Research and Education, University of Maryland, Baltimore County, USA; [3] Division of Science, Information Arts and Technology, University of Baltimore, USA. * bouzeid@princeton.edu

This work summarises the recent publication: Zahn E. Welty C., Smith J.A., Kemp S.J., Baeck M-L, Bou-Zeid E. (2021) "The Hydrological Urban Heat Island: Determinants of Acute and Chronic Heat Stress in Urban Streams", *Journal of the American Water Resources Association*, 57(6), 941-955, https://doi.org/10.1111/1752-1688.12963

Introduction

Urbanization has long been shown to alter the microclimate of cities, leading to the well-known Urban Heat Island effect (Oke, 1982; Oke, 1995) that is often exacerbated during heat waves (Li and Bou-Zeid, 2013; Zhao et al., 2018). Urbanization can increase not only air temperature, but has also been linked to the increase of surface (Oke et al, 2017) and subsurface temperatures (Menberg et al. 2013; Westaway and Younger 2016). However, the associated and concomitant impacts of urbanization on the thermal state of urban streams and water bodies remains less explored than its surface and atmospheric counterparts.

The direct influence of urbanization on water temperature is caused by local and watershed scale perturbations, such as increased exposure to solar radiation caused by decreased riparian canopy cover, decreased forested area in the watershed, and direct inputs of warm water from power plant effluents (Somers et al., 2013; Iezzi and Todisco, 2015; Ketabchy et al., 2019; Reza et al., 2020). Furthermore, one aspect of stream water temperature that is often overlooked is its response to the input of runoff in urban environments. It has been observed that the input of hot runoff can cause temperature surges that increase the stream temperatures by many degrees in periods as short as 15 minutes (Nelson and Palmer, 2007; Rice et al., 2011; Somers et al., 2013; Zeiger and Hubbart, 2015). The most important physical mechanisms generating and transporting hot runoff were discussed by Omidvar et al. (2018) and Omidvar and Bou-Zeid (2019), whose work highlighted the role of urban pavements – with high heat storage capacity – in transferring their heat to rainfall water. This heat exchange results in hot runoff that can substantially increase the stream water temperature, posing a threat to life in aquatic ecosystems.

The main objective of the present study is to characterize the impact of urbanization on stream temperature across 100 streams in the USA. More specifically, we investigate how land cover and hydrometeorological drivers are correlated to the frequency and magnitude of temperature surges during warm months. We further investigate the role of urbanization in exacerbating baseflow stream temperature, i.e., a long-term temperature increase independent of the occurrence of rainfall and temperature surges. Our study elucidates the role of urbanization in exacerbating the frequency of temperature surges, as well as in increasing the baseflow water temperature, creating both a chronic and an acute hydrological urban heat island.

Materials and Methods

Selected sites and data

In total, two years of discharge (Q) and stream temperature (T_S) data from 100 stream gages across 19 states were used. The respective time series have a temporal resolution of 15 minutes or better, and were downloaded from the United States Geological Survey. Additional used data were air temperature, ob-

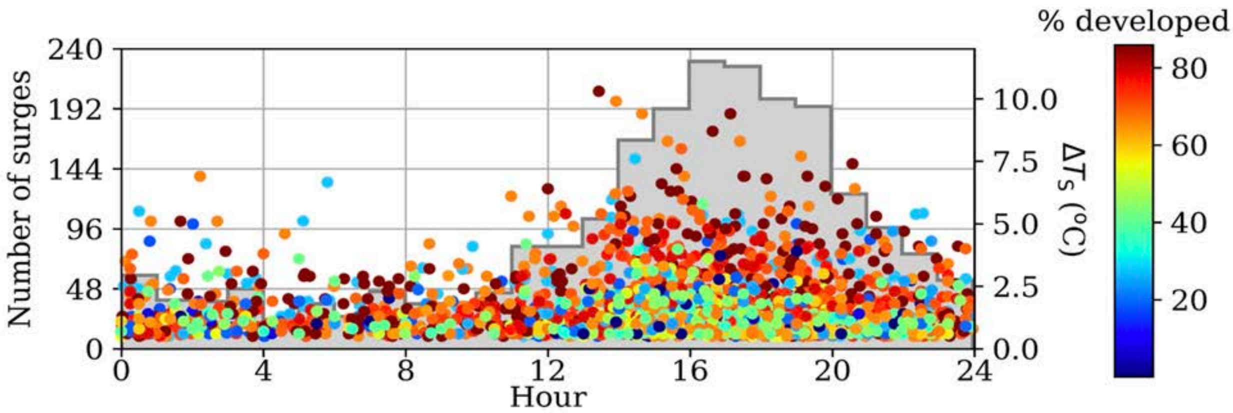


Figure 1. Histogram (gray) of the number of surges per hour (stndard local time) and scatter plot of surge magnitude ΔT_S (n = 2,261). The time refers to the moment a first jump ≥ 0.5 °C was detected. Colors represent the fraction of developed land area in each watershed.

tained from the closest station of the Automated Surface Observing System, and land surface temperature, which was downloaded from the U.S. Landsat Analysis Ready Data (Egorov et al., 2019) through USGS Earth Explorer.

The respective watersheds – defined as the area draining to each gage – were delineated and their land cover categorized following the National Land Cover Dataset (see https://www.mrlc.gov/national-land-cover-database-nlcd-2016). The following characteristics were computed for each basin: percent developed, defined as the sum of low, medium, and high intensity developed areas; percent forest; percent shrubs; percent grass, herbaceous, lichens and moss; and percent pasture/crops. These "green" indices were then combined into a single index called vegetation, which represents the proportion of the watershed that is covered by any type of vegetation (natural or agriculture), having soil with larger permeability than regions with built surfaces, such as roads or compacted urban soils.

Hydrometeorological descriptors were mean baseline stream $T_{S,0}$ and air $T_{A,0}$ temperatures, and baseline discharge Q_0. The overbar denotes the average over all surge events for each gage. These averages were only computed for a stream that registered at least ten surges in the two analyzed years (2017 and 2018).

To characterize the temperature gradient between the land surface and the water, we defined the overheating index (OHT). This index is defined as the difference between the spatial average of the satellite-measured land surface temperature (T_L) and the temporal average of the stream temperature over a single typical day with available satellite image. Only one estimate of OHT was thus derived for each watershed, with the respective images selected from sunny days with low cloud coverage, and occurring during the warmer months of the year (different watersheds may thus have their OHT computed over different days).

Temperature Surge Metrics

We defined a stream temperature surge as an increase in stream temperature of at least 0.5 °C over a 15-min window, associated with a concurrent increase in stream flow. Its magnitude is computed as

$$\Delta T_s = T_{S,\,peak} - T_{S,0}$$

where $T_{S,\,peak}$ and $T_{S,0}$ are the maximum stream temperature during a surge and the temperature immediately before the surge, respectively. Another relevant metric describing the advective heat stress is the event mean temperature (EMT),

$$EMT = \frac{\int_0^t \Delta Q \Delta T_s\, dt}{\int_0^t \Delta Q\, dt}$$

where *t* is the time the stream temperature reaches its peak value. In our analysis we compute the 90th percentile of the EMT distribution for each gage, which is later correlated to land surface and hydrometeorological parameters.

To represent surge frequency, we calculated the fraction of days with surges, given by the ratio of days with at least one surge by the total number of investigated days. Finally, to investigate the baseflow stream temperature, we isolated all days that did not register any temperature surge, considering these days as "undisturbed" (as opposed to "disturbed" by the input of hot runoff in days with surges). We then computed the peak daily stream temperature considering only

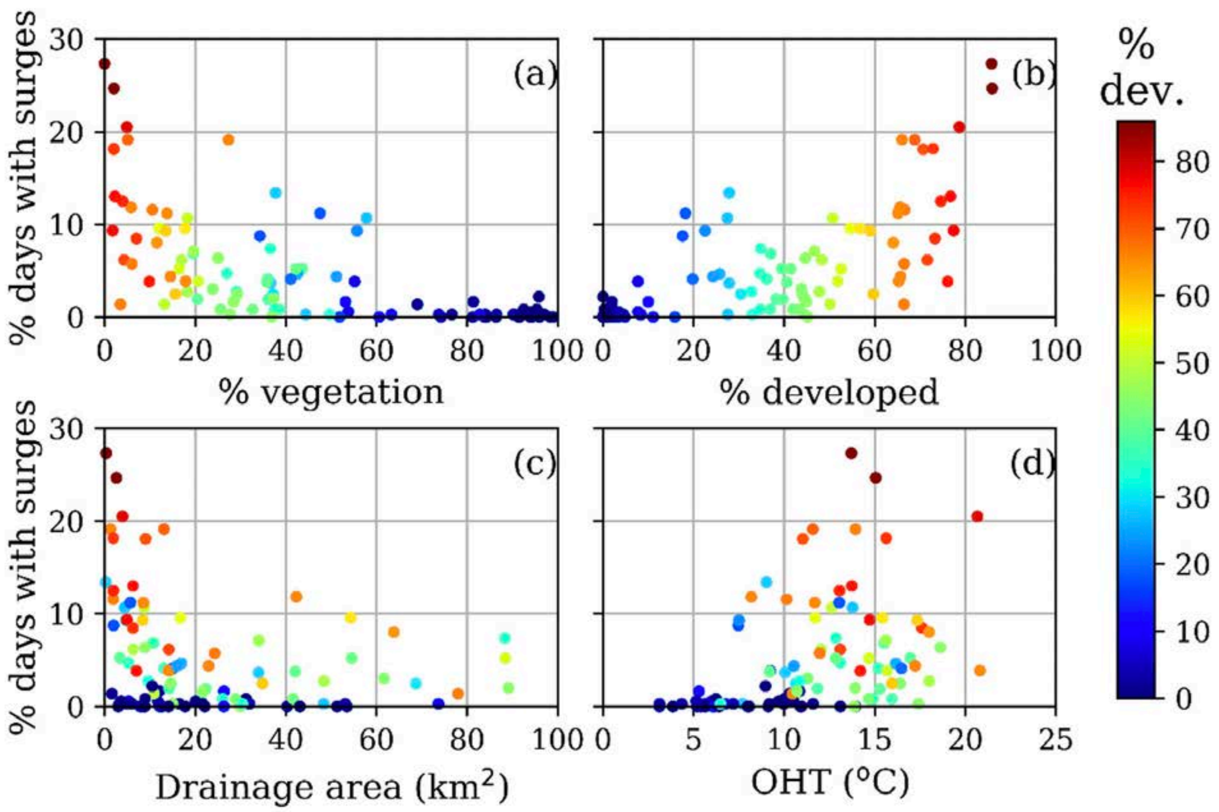


Figure 2. Plot of % of days with surges vs. (a) percent vegetation, (b) percent developed fraction, (c) drainage area, and (d) overheating of the watershed (OHT). In all plots, the colors represent the percent developed fraction in the respective watershed.

undisturbed days. These values were later contrasted to maximum temperatures achieved during a surge, indicating that streams with the highest background temperature values (on undisturbed days) were more likely to be further exacerbated by the input of hot runoff.

Results and Discussion

Temperature surge statistics

In total, 2,261 surges were identified during the warmer months of the year (mid-April to mid-October). From the set of 100 investigated streams, 53 registered at least ten surges in the two analyzed years, the most extreme case being 155 surges (covering 27% of the total number of investigated days in this stream).

Nearly 69% of the surges were greater than or equal to 1.0 °C, while 28% were greater than or equal to 2.0 °C. Furthermore, a smaller proportion (≈3.4%, 77 surges) were in the range 5.0-10.3 °C, found more often in the most developed watersheds (Figure 1).

According to Figure 1, temperature surges were more frequent in the afternoon, with a peak around 4 pm. It is also noticeable that increases greater than 6.0 °C were almost entirely restricted to the period between noon and 8 pm. These results show a general picture in which rainfall events in the afternoon – when the land surface is hot due to intense and prolonged insolation – lead to a runoff with higher temperature than the receiving stream. In addition, despite the hottest surges being registered during daylight hours, surges as high as 7.6 °C were observed between midnight and 6 am, illustrating the potential of these pavements to remain hotter than their surroundings hours after sunset.

Surge frequency and magnitude versus land cover

The scatter plot of the number of days with surges versus area and land surface descriptors confirms the strong connection between surge frequency and the degree of development in the watershed (Figure 2b), also reflected in the fraction of vegetation (Figure 2a). Watersheds with a large vegetated area reduce the surface temperature and increase its permeability, reducing the runoff temperature by both decreasing heat advection and delaying its generation. In contrast, streams that exhibited surges in more than 10% of days were located primarily in watersheds that are more than 60% developed. Nonetheless, some urban streams registered few surges, showing that development is a necessary but insufficient condition for a high frequency of surges.

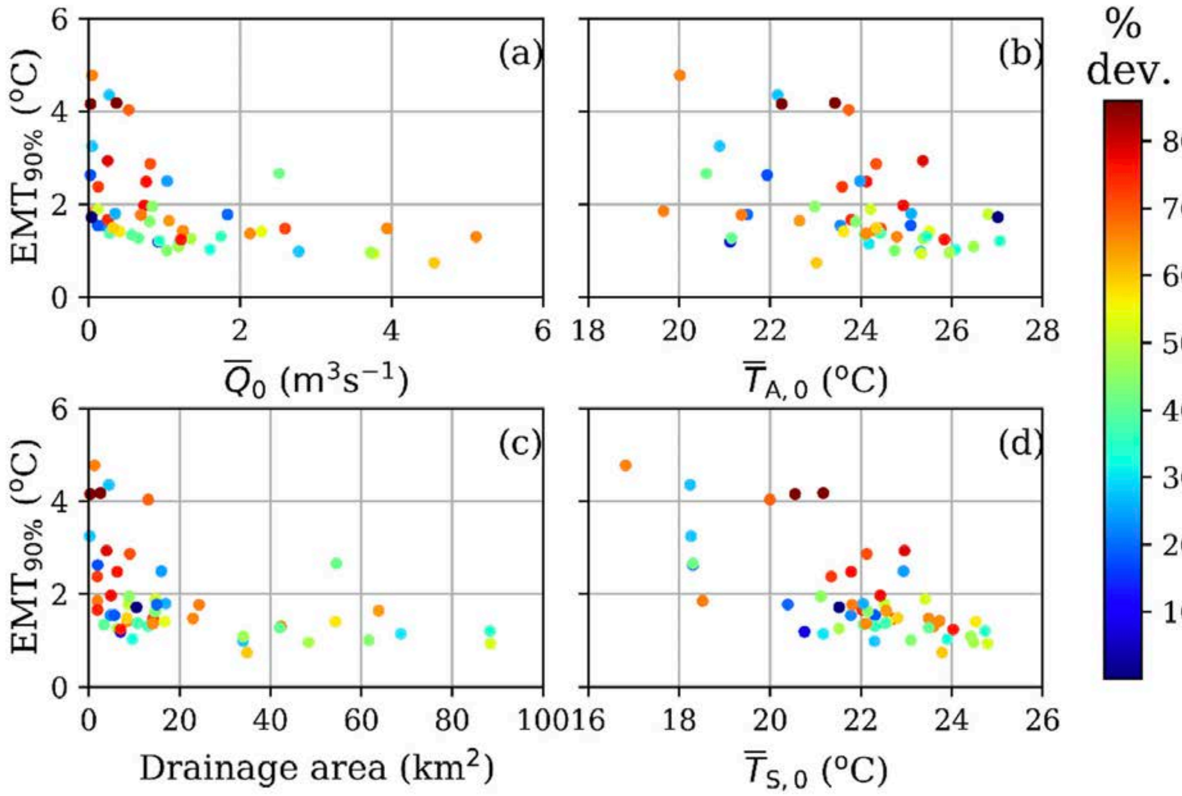


Figure 3. Plot of 90th percentile of EMT vs. (a) mean baseline discharge, (b) mean baseline air temperature, (c) drainage area, and (d) mean baseline stream temperature, where baseline refers to the state immediately before surge. Mean values were computed over all temperature surge events for each gage.

Temperature surges are also more frequent in smaller watersheds (Figure 2c) and those with a higher gradient between land surface and water temperatures (Figure 2d). All watersheds with surge frequency >15% had an OHT larger than 10 °C, meaning that the land surface in these watersheds is at least 10 °C hotter than the stream on a typical sunny day. However, there are gages with large OHT but few or no surges, as can be seen for less developed watersheds (developed fraction 20%). This indicates that natural surfaces, even when they can display large overheating relative to the stream, do not generate temperature surges due to larger infiltration and higher storage, resulting in a lower and slower runoff. The presence of an envelope curve – not only for OHT but for all other explanatory variables – highlights the complex interaction of many drivers in generating temperature surges.

Surge intensity as a function of watershed characteristics and hydrometeorology

Drainage area is the watershed characteristic that best explains the 90% percentile of the event mean temperature, EMT$_{90\%}$ (Figure 3c). Surprisingly, despite percent development being highly correlated with surge frequency (Figure 2a), it is not a good descriptor of the intensity, being poorly correlated to EMT$_{90\%}$ (Spearman correlation of 0.26, scatter plot not shown). Furthermore, the overheating index also resulted in a smaller than expected correlation with EMT$_{90\%}$ (Spearman r=0.01, scatter plot not shown). However, this correlation could be affected by the use of one land surface temperature image for each watershed taken on a sunny day, thus not showing temporal variation of T_L or the conditions prevailing before rainfall that tend to be cloudy.

Looking at stream and air temperatures immediately before the surges, we found that the smaller these baseline values, the larger ΔT_S and consequently EMT$_{90\%}$ (Figure 3b). The negative correlation (Spearman correlation coefficient of -0.65, $p<0.05$) between EMT$_{90\%}$ and $\overline{T}_{S,0}$ is an expected result – especially in smaller streams – which follows from the large temperature difference between the cooler baseline water body and the heated runoff water it is receiving. Large temperature surges occurring in cooler baseline temperatures can be seen in well-shaded streams where riparian vegetation prevents part of the solar radiation from reaching the water. In our study, this was observed to occur in some of the most urbanized watersheds investigated, located in Baltimore, MD, Washington, DC, and Atlanta, GA. Nonetheless, while these streams might be well shaded – keeping their

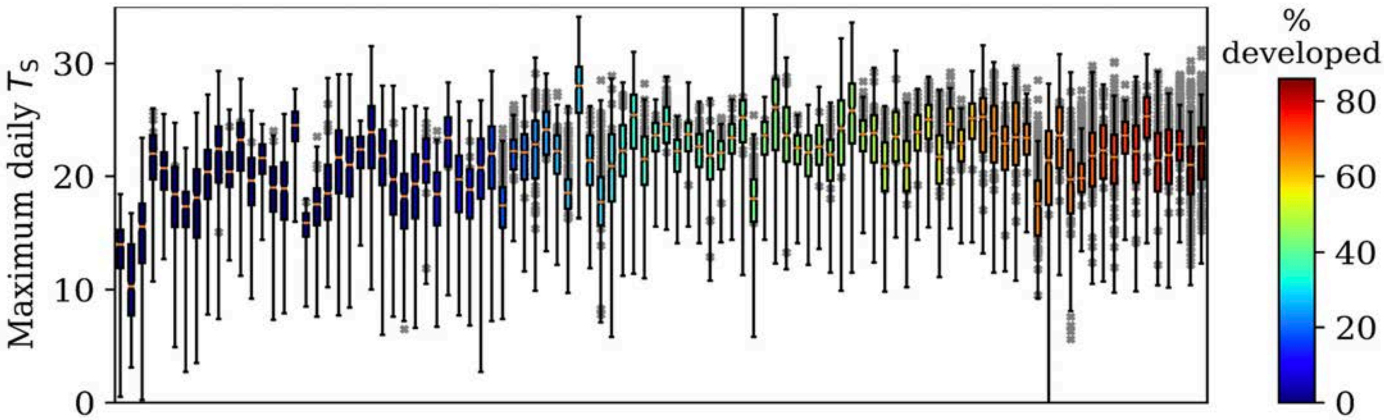


Figure 4. Boxplot of maximum daily stream temperature on undisturbed days (when no surge occurred) registered at each gage. Upper and lower whiskers are the maximum and minimum values, while the box size is the interquartile range. Gray markers are the maximum stream temperatures observed during surge events. Only days between April 15 and October 15 of 2017 and 2018 are included.

water temperature cooler – their urban surroundings still transfer hot runoff to them, creating rapid temperature surges.

Implications for thermal stress and ecosystem health in urban streams

In the previous section we investigated how land cover characteristics and hydrometeorological parameters explain surge frequency and magnitude. Now we further investigate how the same explanatory variables correlate to the maximum stream temperature attained during surges, $\overline{T}_{S,peak}$. This variable was found to be highly correlated to the mean air ($\overline{T}_{A,0}$) and stream temperature ($\overline{T}_{S,0}$) before surges. This means that watersheds with high air or stream baseline temperatures also resulted in the highest temperature peaks after surges. Although this may seem like an obvious result, it highlights that streams that are already disturbed by urbanization – being hotter than "vegetated" streams — are further impacted by temperature surges. Nonetheless, we note that the streams with largest $\overline{T}_{S,peak}$ were not necessarily streams with larger developed fraction (although still highly developed), and this is likely the result of the confounding and complex effect of other factors, such as shading, that can reduce peak temperatures even in highly developed streams.

So far, we have shown that temperature surges can increase stream temperature by up to 10.3 °C and are more common in developed watersheds. However, the peak temperatures reached during these surges were also strongly modulated by the stream's baseline temperature that was affected by drainage area, shading, and factors not directly related to urbanization. One important remaining question is thus to what extent does urbanization alone modify the baseline temperature observed in these streams? That is, does urbanization increase baseline temperature as well as surges, thus creating a synergistic risk to stream health?

To answer this question, we plot the distributions of maximum daily stream temperature on undisturbed days (when no surge occurred) in Figure 4, where upper and lower whiskers represent maximum and minimum values and the size of the box corresponds to the interquartile range. Boxplots were ordered in the figure by percent developed area as indicated by the colorbar. The figure also shows $\overline{T}_{S,peak}$ in grey markers, i.e., the maximum temperature achieved during a temperature surge for all surge events in each stream. Thus, $\overline{T}_{S,peak}$ happened on "disturbed" days, but may or may not correspond to the maximum stream temperature observed on the respective day.

The average daily maximum T_S increases almost linearly with percent developed area in the watershed (Spearman correlation coefficient r=0.45). Some of the most developed sites (developed area > 70%) seem to show a moderate decline in T_S compared to sites with intermediate development, but this is likely caused by local factors as previously mentioned. Nonetheless, these results indicate that stream temperature on undisturbed days, which represents a "background" state, tends to be warmer in more developed basins as a result of other direct and indirect urbanization impacts (Rice et al., 2011; Rice and Jastram, 2015). In addition, streams in more developed watersheds not only registered more surges, but also had more cases where the maximum temperature after a surge was larger than the maximum temperature on undisturbed days. For instance, the most developed watershed registered a temperature peak caused by a surge that was 4.0 °C larger than the maximum value registered considering all undisturbed days. Even when not larger than the baseline temperatures, $\bar{T}_{S,peak}$ is usually in the upper range of the distribution of maximum temperature on undisturbed days.

Our findings thus indicate that urban streams are altered in two main ways: chronic – caused by long term warming, and acute – caused by temperature surges. These results thus confirm the existence of a hydrological urban heat island (HUHI), which refers to an increase in the temperature of urban streams (and potentially other surface water bodies) compared to their vegetated counterparts. These impacts are directly linked to urban modifications in the environment surrounding such streams as our analysis confirms: if the same streams were located in undisturbed or less urbanized regions, baseline temperatures would be lower and runoff temperature surges would be less frequent.

The possible consequences of increased temperature in aquatic ecosystems are myriad. For instance, it may increase the rates of microbial decomposition and primary production (Scrine et al., 2017; Demars et al., 2011), alter the rate of chemical reactions (Kaushal et al., 2018), disturb ectothermic aquatic organisms (Scrine et al., 2017) and migration patterns (Krause et al., 2004; Scrine et al., 2017). The characterization and understanding of the HUHI phenomenon and its drivers are thus important steps towards mitigation measures.

Conclusion

We investigated temperature surges and their main drivers across 100 stream gages in the United States. We identified that development in the watershed is the main explanatory variable of surge frequency, indicating that the most urban watersheds are expected to have more temperature surges. In addition, the smaller watersheds are expected to experience the highest rates of temperature change, threatening aquatic life in first order streams located in highly urbanized regions. One important finding of this study is that the already warmer stream temperature in the most developed regions is further exacerbated by temperature surges.

This increase in water temperature in developed cities, compared to their rural or suburban counterparts, is here defined as a Hydrological Urban Heat Island. This phenomenon is driven by the same urban land use modification that modulate surface and air UHIs (and subsurface UHI to a lesser extent), and therefore it would be remiss not to link them and seek common mitigation measures.

Acknowledgements

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A patchwork of clouds covers the skies above Princeton, New Jersey on May 27, 2016.
(Photo: David Pearlmutter)

Numerical simulations of the outdoor thermal environment: past trends and future directions

This work summarises the recent publication (with Figure 1 showing the graphical abstract):
Lam, C.K.C., Lee, H., Yang, S.-R., Park, S. (2021) "A review on the significance and perspective of the numerical simulations of outdoor thermal environment." *Sustainable Cities and Society*, 102971. https://doi.org/10.1016/j.scs.2021.102971

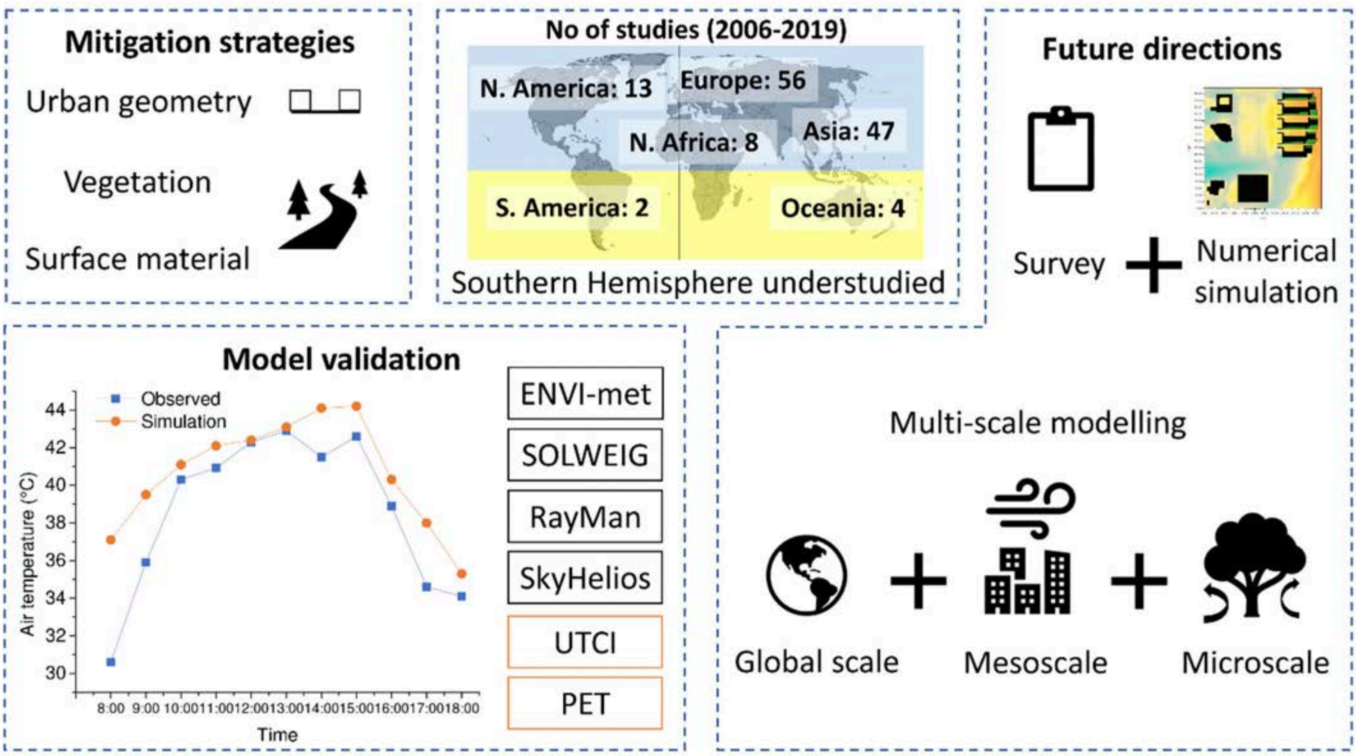


Figure 1. Graphical abstract of the review paper.

Computer simulations of outdoor thermal comfort

This review focused on 130 studies from 2006 to 2019 that employed different models relating to outdoor thermal comfort. Most studies used simulation software such as ENVI-met, RayMan, and SOLWEIG (Figure 2). The analysis of applied thermo-physiological assessment indices shows that the predominantly used indices are the Physiological Equivalent Temperature (PET) and Universal Thermal Climate Index (UTCI). The PET was widely used in studies conducted before 2009, and the application of PET increased rapidly from 2015. Although the PET was introduced in 1987, it is still used in many studies that evaluate human heat perception. Since 2012, the UTCI has been applied to studies on outdoor thermal comfort.

Model validation

The simulation results should be validated against field measurements to establish confidence and gain useful insights (Oke et al., 2017). In this study, 61% of the papers compared computer simulation results with the measured data. The validation of air temperature (T_a) and mean radiant temperature (T_{mrt}) was widely pursued among all climatic factors (59 and 35 papers, respectively). The human thermal indices were validated in only 10% of papers: 7 papers using PET, 3 papers using UTCI, and 2 papers using Predicted Mean Vote (PMV) and Standard Effective Temperature (SET*).

If more than one climatic factor were the main aspects of studies (e.g., T_a, relative humidity: *RH*, wind speed: *v*, and/or T_{mrt}), simulation results should be compared with the observation data for validation. Moreover, both the coefficient of determination (r^2) and real differences between the simulation results and observation data should be checked. If the differences were sufficiently large to change human thermal comfort levels despite the r^2 being high, adjusting methods (e.g., formulas) should be explored to reduce the differences for further analysis.

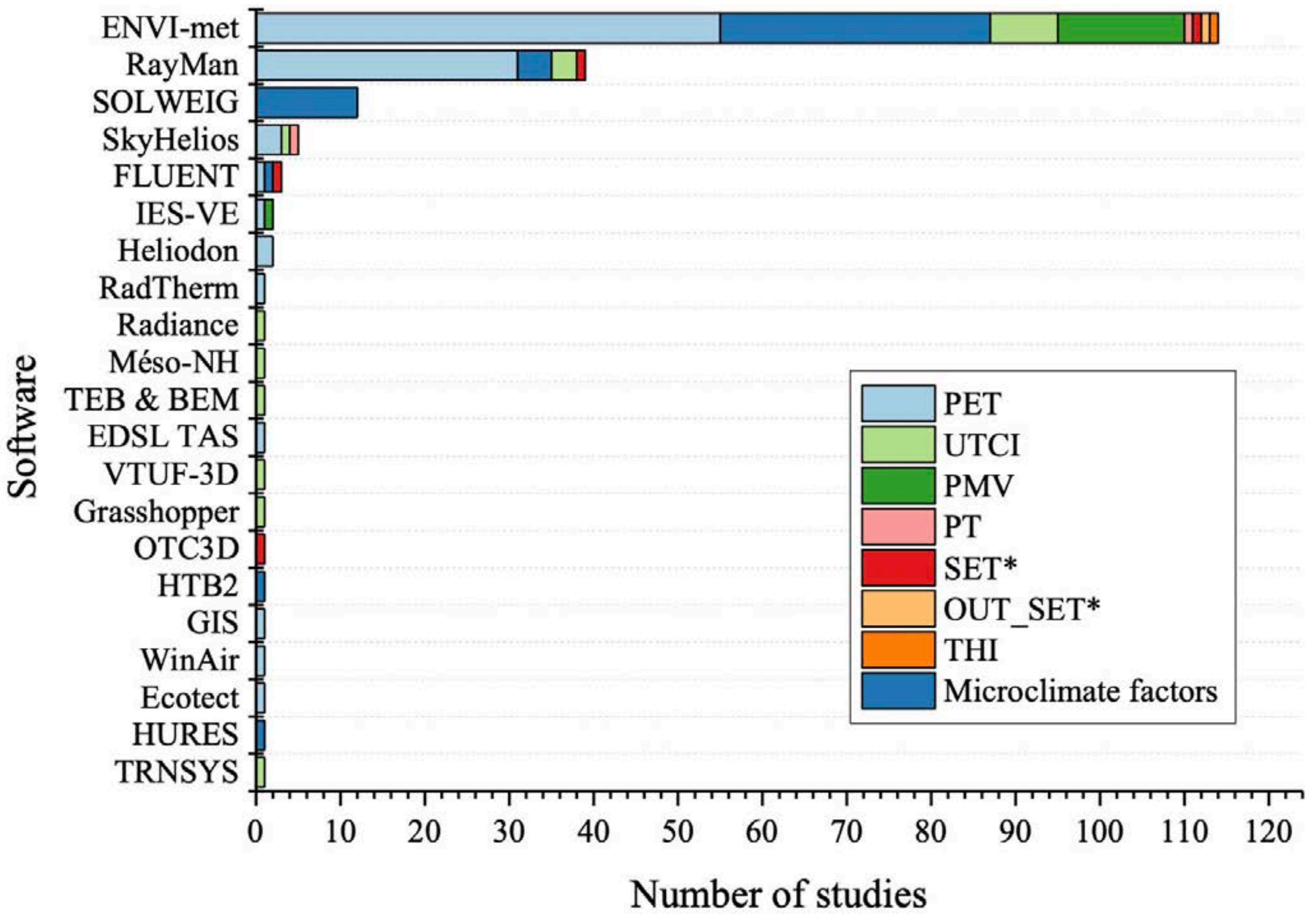


Figure 2. Frequency of the reported thermo-physiological assessment indices of each numerical simulation model.

In addition, a high r^2 in one climatic factor, e.g., T_a, cannot guarantee the confidence of other factors. Human thermal comfort is affected mainly by T_a, RH, v, and T_{mrt}. Therefore, for human thermal comfort analysis, the four climatic factors should be observed in situ and used in the validation processes. Moreover, their calculation in the model should be identified and, if necessary, adapted to the simulation results. The adjusted results could then be used for further analysis.

Geographical distribution of studies

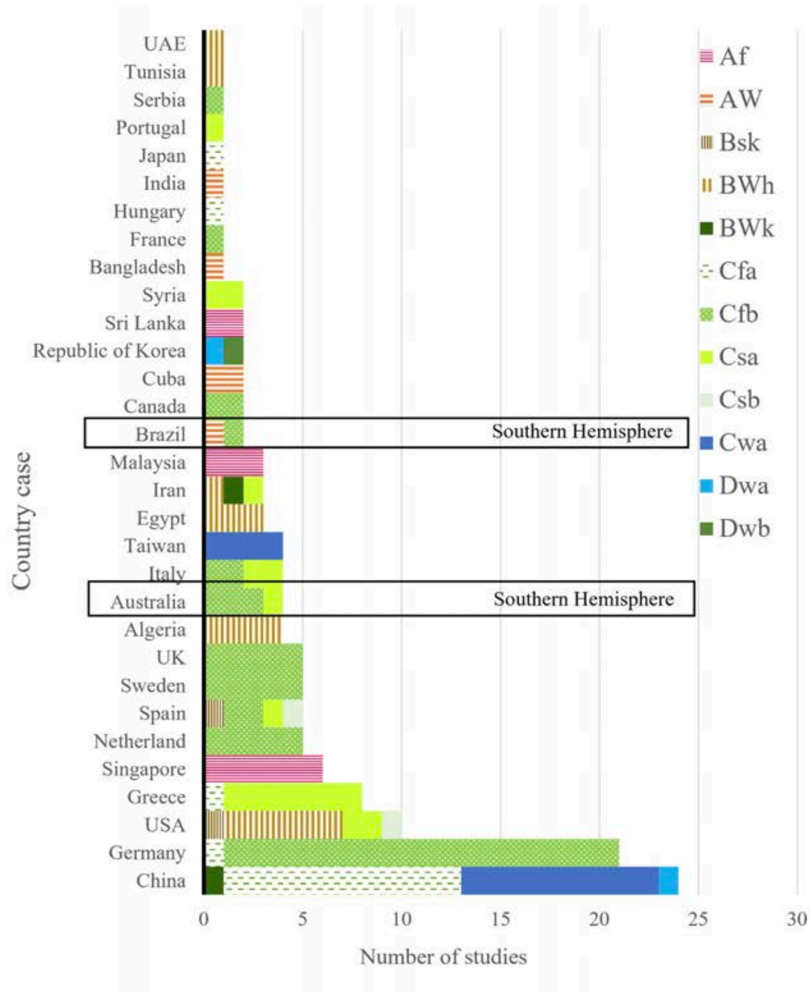
Most previous studies have been conducted in the Northern Hemisphere, but very few in the Southern Hemisphere (Figure 3). Many study areas are in the temperate oceanic climate (Cfb, 50 studies), followed by the hot-summer Mediterranean climate (Csa, 19 studies), hot desert climate (BWh, 16 studies), and humid subtropical climate (Cfa, 16 studies).

Most studies have simulated the outdoor thermal environment during summer (Figure 4). Contrary to our expectation, studies in cold climatic regions (e.g., BSk, see Figure 3) examined summer conditions rather than winter conditions (Tumini et al., 2016; Zhao et al., 2018). In the review studies considered here, most studies have focused on typical summer/hot days with sunny weather (121 studies), followed by typical winter/cold days (21 studies). Extreme weather phenomena caused by climate change have increased in both frequency and intensity (Stott, 2016). Future research can investigate the impact of heatwaves or extreme weather on outdoor thermal comfort, which can provide people with corresponding adjustment strategies in the face of environmental extremes and inform preliminary environmental planning.

Mitigation strategies to improve the outdoor thermal environment in urban areas

Mitigation strategies include changing the urban geometry (aspect ratio, building, and street orientation), urban vegetation, and surface materials. Many studies have explored the impact of various aspects of urban greenery, cool materials, and changes in surface albedo.

Past Northern Hemisphere studies found that the E–W street canyons would have higher heat stress than that of the N–S street canyons (Ali-Toudert and Mayer, 2007; Lobaccaro et al., 2019), but Taleghani et al. (2015) reported no difference. Moreover, the lack of studies on asymmetrical aspect ratio might be due to limited observational data for model validation. Chen et al. (2020) suggest that observation data in scaled outdoor exper-



Climate zone	Climate zone definition
Af	Tropical rainforest climate
Aw	Tropical wet and dry
BSk	Cold semi-arid climate
BWh	Hot desert climate
Cfa	Humid subtropical climate
Cfb	Temperate oceanic climate
Csa	Hot-summer Mediterranean climate
Csb	Warm-summer Mediterranean climate
Cwa	Monsoon-influenced humid subtropical climate
Dwa	Monsoon-influenced hot-summer humid continental climate
Dwb	Monsoon-influenced warm-summer humid continental climate

Figure 3. Types of Köppen climate in each study country. Please note that certain papers include multiple study locations and climate zones.

iments can be used to validate the findings of modelling studies regarding ventilation and radiation fluxes in street canyons with various aspect ratios.

We observed a research trend that places a greater focus on the vegetation's effect on thermal comfort at a finer scale and a more accurate parameterization of vegetation in the simulation model. Earlier studies are interested in overall greenery and building coverage (Ng et al., 2012; Wong et al., 2007). In contrast, more recent studies focused on variations in leaf density distribution per height and vegetation arrangement at the street level (Lobaccaro et al., 2019; Zhao et al., 2018). The effectiveness of tree shade depends on sufficient water supply and appropriate location leading to ventilation for cooling, which could explain the contrasting findings in the cooling effects of trees (Meili et al., 2021).

There has not been a consensus in the literature regarding whether increasing surface albedo improves pedestrian thermal comfort (Jamei et al., 2016). The reflectivity of a surface depends on its color and roughness. Reflective pavements are known as a heat mitigation strategy (Lai et al., 2019). However, some modelling studies discovered that increasing the albedo of the ground surface would increase the thermal stress for pedestrians (e.g., higher T_a, T_{mrt}, and PET) (Lobaccaro et al., 2019; Taleghani, 2018). Without appropriate observational data for validation, it is difficult to parametrize the changes in the albedo of surface materials in simulation software owing to aging effects and different shading conditions. These issues might explain the lack of such studies in the literature. Considering the issue of albedo, it is necessary to calculate the albedo effect considering various conditions in an urban area and improve the model function of heat transfer processes.

Future research directions and collaboration ideas

Surveys and direct observation can be used to identify hot spots or places and the time of the date or season that require intervention to reduce heat stress. Researchers can then use simulation software to identify the appropriate heat mitigation strategies for the hot spots identified from surveys or direct observation. We encourage more studies to combine surveys and numerical simulations in various climatic regions, which could

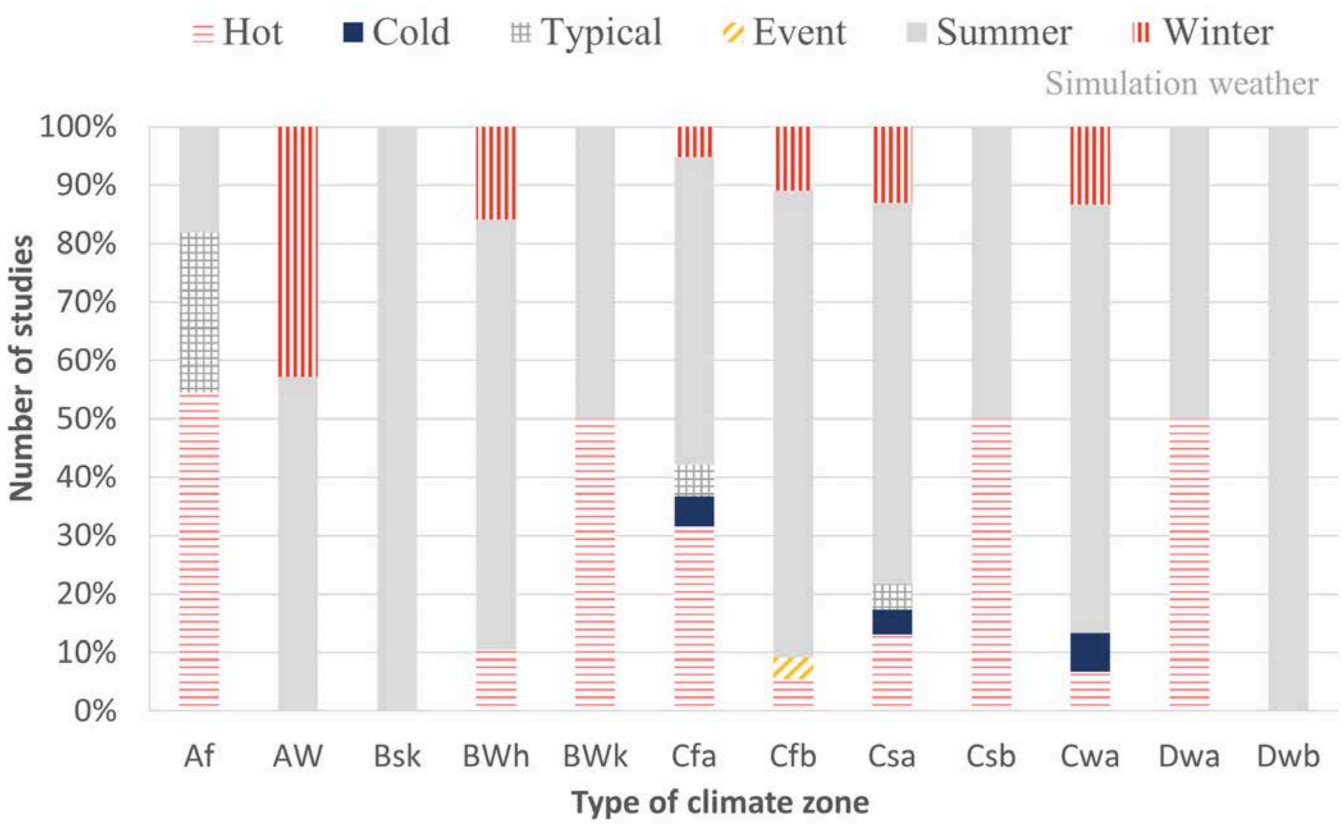


Figure 4. Simulation weather in different climate zones.

provide further insight into the effectiveness of heat mitigation strategies in different climates.

We observed an emergence of new research on the impact of climate change on the urban thermal environment at the microscale (Aminipouri et al., 2019). Such a study involves the coupling of the global circulation model (GCM), and mesoscale and microscale models (Conry et al., 2015). The GCM output can be input to a mesoscale model (e.g., Weather Research and Forecasting Model: WRF) that uses a complex urban canopy parameterization (UCP) scheme to characterize near-surface processes. Moreover, ENVI-met could be linked with the Local Climate Zone (LCZ) classification using the World Urban Database and Access Portal Tools (WUDAPT) scheme (Ching et al., 2019). A high-resolution model area (ENVI-met) can be nested into a larger scale model domain in the WUDAPT or mesoscale model, such as WRF. In this way, large-scale processes can be included in microscale simulations (McRae et al., 2020). This emerging research field is an opportunity to facilitate new collaborations between researchers focusing on different spatial scales, which can address the challenge of future climate change and hotter urban climates.

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Cho Kwong Charlie Lam
School of Atmospheric Sciences, Sun Yat-sen University, Zhuhai, China
linzug@mail.sysu.edu.cn

Shing-Ru Yang
Department of Interior Design, Tainan University of Technology, Taiwan
c9052002@hotmail.com

Hyunjung Lee
Dept. of Urban Climatology, Office for Environmental Protection, City of Stuttgart
Hyunjung.Lee@stuttgart.de

Sookuk Park
Department of Horticultural Science, Jeju National University, Republic of Korea
sooland@jejunu.ac.kr

The Urban Heat Island: A Guidebook

By Iain D. Stewart and Gerald Mills

Stewart I.D. and G. Mills. (2021) *The Urban Heat Island: A Guidebook.* Elsevier.

The study of the urban effect on temperature has been synonymous with the field of urban climatology since its scientific origins over two hundred years ago. The observation of the urban heat island (UHI), especially its near-surface (canopy) and surface manifestations, has produced a very large body of work but, despite its lengthy history, there are no established guidelines.

Book summary

The Urban Heat Island: A Guidebook consolidates many years of teaching experience in different contexts where prior knowledge may be limited and access to resources is variable. The book is a best-practice guide to plan an observational study of the urban temperature effect; to analyse and interpret the data collected from the field; and to communicate the results to their intended audiences. It is written for novices in the field of urban climatology for whom the UHI phenomenon is their first direct encounter with climate research; however, it is also suitable for experienced workers in the field who may be less familiar with the formalities of heat island investigation. The *Guidebook* aims to give students, researchers, and educators an established set of tools and methodologies with which to study heat island effects and their societal implications. The focus is canopy-level and surface UHIs that together make up the great majority of heat island studies.

Topics covered

There are two main parts to the book: the first part outlines the physical processes responsible for the UHI and common actions used to manage it; the second part presents methodological guidelines for canopy and surface UHI studies. In Chapter 1, the heat island phenomenon is introduced, and a case is made for its continued examination despite the extensive body of work already in place. Chapters 2 and 3 explain the causes of UHI formation and how excessive heat in the city can be managed through urban planning and design strategies. Chapters 4, 5, and 6 establish a methodology to observe the canopy and surface heat islands, with the latter focused mainly on the role of satellite remote sensing. Each of the three methodological chapters concludes with a checklist of items for the researcher to consider before, during, and after a heat island study. Chapter 7 brings the book to a close with a review of guiding principles for all UHI investigators to follow:

• *Know your UHI history.* Historical awareness allows you to build upon the successes of previous work, and it gives you the knowledge to ask valid questions for further research.

• *Be confident in your understanding of the UHI phenomenon.* This refers to the physical processes that drive the heat and energy exchanges and stores of the surface, substrate, and near-surface atmosphere. These processes make clear the distinction between heat island types, namely those of the surface, subsurface, canopy, and boundary-layer atmospheres.

• *Link your choice of a UHI type to study to a specific problem or curiosity.* This is especially true of heat mitigation work because the thermal effects to be measured (and ultimately managed) in a city may require observation of air and/or surface temperatures.

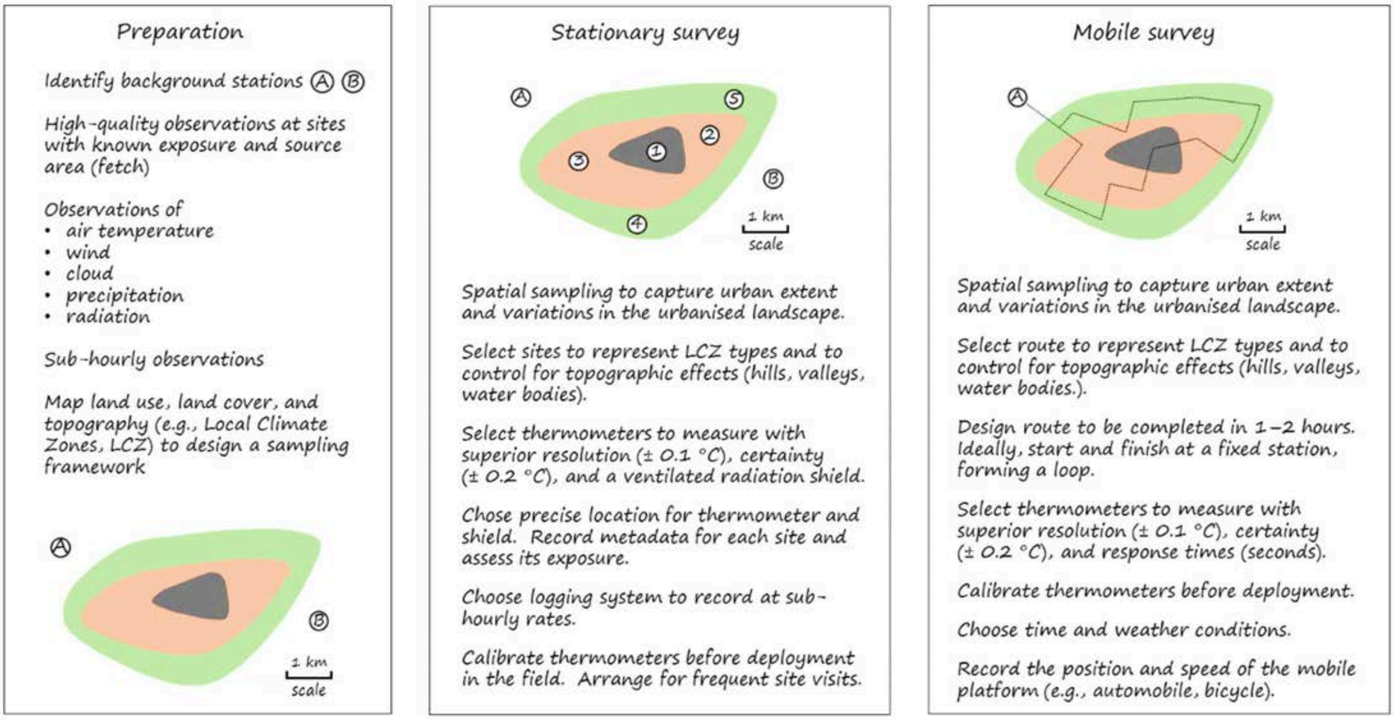

Figure 1. Planning a canopy-level urban heat island study.

• *Follow established protocols to collect, analyse, and document your work.* This enables comparisons of your work with that of others, and it accelerates scientific progress in the field.

Core chapters

Each of the core chapters (4–6) on heat island methodology begins with a set of considerations for the researcher to implement the work. While some of these are contemplative in nature ("Who is the audience?") and others are prosaic ("What resources are available?"), all require seriousness and patience to meet an appropriate response. To start, readers are faced with a most fundamental thought: "What is the purpose of your study?" This is not an easy or straightforward question, but the response to it will influence almost every decision to be made at subsequent stages of the work.

In Chapter 4 ("Planning a Canopy UHI Study), we attend to each of these general considerations, then move to more specific guidelines for planning a heat island study. The guidelines are targeted to the methods, instruments, and definitions of heat island measurement, and include practical instructions for deploying temperature sensors across urban and rural areas. Heat islands in the canopy layer are conventionally measured with ground-based methods involving stationary surveys (i.e., sensors placed at fixed points in and around a city), and/or mobile surveys (sensors transported by foot, automobile, bicycle, or motor scooter). We illustrate with schematic diagrams how stationary and mobile surveys are a simple means to measure locally representative air temperatures in cities of any size, location, or description (Figure 1). We also describe the main differences between the two approaches in terms of their resource needs, data yields, primary uses, experimental controls, and notable drawbacks (Table 1). These qualifications allow researchers to make educated decisions about study methods, goals, and outcomes. Chapter 4 concludes with a short checklist to summarise the planning process. The list is structured to ensure accuracy, consistency, and completeness of the work.

1. Ask questions

a) What is the problem, issue, or curiosity you wish to investigate?

b) What resources are available to you (e.g., time, equipment, finances)?

c) Who is your audience (e.g., scientists, policy makers, lay citizens)?

2. Choose a study method

a) Select mobile and/or stationary surveys. Be sure to align these with the aims and resources of your study.

b) Determine the instruments needed, and keep in mind their technical specifications.

c) Follow international guidelines to install and house the thermometers.

3. Design a sampling framework

a) Identify sites and survey routes that are representative of the local scale. Site maps and site visitations are essential in this process.

b) Determine sampling frequencies and density of measurements. These must align with the time and space scales of your study.

Table 1. Summary of differences between stationary and mobile UHI surveys.		
	Stationary surveys	**Mobile surveys**
Primary uses	To observe (i) the climatology of heat islands; (ii) the combined and/or separated effects of heat islands and global warming; (iii) the seasonal and/or annual temperature conditions inside LCZs; (iv) the heat island magnitude over time and with environmental change.	To observe (i) the local and microscale effects on heat island magnitude and morphology; (ii) the statistical relations between heat island magnitude and urban geometry, land cover, and daily weather (wind, cloud); (iii) the microscale temperature variations inside LCZs.
Resource needs	Climate stations and/or temperature sensors at fixed locations in and around the city. Minimum of two locations (one urban, one rural), preferably a network of multiple urban and rural stations.	Mobile platforms (e.g., automobiles, bicycles). One or more temperature sensors, data loggers, and GPS units. Field assistants to help with data collection and transport of equipment.
Duration of field campaigns	Usually long – several seasons or years.	Usually short – several days or months.
Temporal resolution of survey data	Usually high – sampling frequency may be continuous or short time-intervals (seconds, minutes) throughout the campaign.	Usually low – sampling periods typically last a few hours and are infrequently repeated during the campaign.
Spatial resolution of survey data	Usually low – depending on the number of stations or sensors in the study area (i.e., sampling density).	Usually high – depending on the number of measurements taken along the survey route (i.e., sampling frequency).
Locally representative sites	Difficult to achieve with pre-existing climate stations or temperature sensors, especially if sited for purposes other than heat island observation. Possible with careful siting of fixed sensors.	Easy to achieve with careful design of survey routes and selection of sites. If measurements are made at short time-intervals (seconds), not all sites will be locally representative.
Experimental control	Control of surface effects (relief, urban form) is difficult due to low (and often pre-determined) spatial resolution of the measurement sites. Control of time (synchronous measurement) and weather effects (wind, cloud) is simpler due to long duration of field campaigns, large sample sizes (number of repeated observations), and automated measurements.	Control of surface effects (relief, urban form) and weather effects (wind, cloud) is simple due to high spatial resolution of measurement sites, and opportunity to sample where/when desired (range of times, sky conditions). Control of time (synchronous measurement) is difficult due to low temporal resolution of sampling periods, the need for time-temperature correction, and small sample sizes (number of repeated observations).
Notable drawbacks	Difficult to find safe, secure, accessible, and locally representative sites. If pre-existing stations or sensor networks are used, these are often of low spatial resolution or without site metadata. Volunteer, amateur, and crowd-sourced networks increase the quantity of data, but reduce the quality.	Survey routes are usually restricted to public roads. Roads may not be representative of the local area through which they pass. In large cities, it is difficult to cover the entire urban area in a reasonable time period. Late-night data collection required to observe the maximum heat island magnitude.

c) Configure the measurement sites to control for unwanted effects on UHI magnitude (e.g., weather, surface relief, water bodies).

4. *Define the UHI magnitude*

a) Choose definitions that are relevant to your audience. Consider city scale (urban-rural) and local scale (LCZ) indicators.

b) Evaluate the need for spatial and temporal averaging in your definition.

Book availability

By agreement with the publisher, a pre-publication version (PDF) of the Guidebook is available for free download on the IAUC website by members of the urban climate community. Alternatively, members can email Gerald and Iain directly to request the book PDF.

Gerald Mills
gerald.mills@ucd.ie

Iain D. Stewart
iain.stewart@utoronto.ca

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Upcoming Conferences...

The information in this list is current as of the publication date of the newsletter, but readers should check for updated information online in the event of schedule changes due to the COVID-19 pandemic.

102ND AMERICAN METEOROLOGICAL SOCIETY ANNUAL MEETING AND 22ND JOINT CONFERENCE ON THE APPLICATIONS OF AIR POLLUTION METEOROLOGY, Session on "Urban Air Pollution under a Changing Climate and Changing Emission Profiles"
Houston, USA • January 23-27, 2022
https://annual.ametsoc.org/index.cfm/2022/

URBAN MULTI-SCALE ENVIRONMENTAL PREDICTOR (UMEP) SEMINAR
Open online • January 27, 2022 (1-4 pm CET)
Registration (deadline January 15, 2022) at:
https://forms.office.com/pages/responsepage.aspx?id=Me2YB7D1NUmGPHPuJQWAbiRWAvvrn-5JgwfssEoT7yhURUtEMUU4Q1NYV1JNTUxDVFo5MFAzUDQxSi4u

13TH INTERNATIONAL CONFERENCE ON SOUTHERN HEMISPHERE METEOROLOGY AND OCEANOGRAPHY (ICSHMO), Session on Urban Climate
Christchurch, New Zealand • February 8-12, 2022
https://confer.eventsair.com/icshmo-2022/

QUATERNAIRE 13: PALAEOCLIMATE CHANGES, LANDSCAPE EVOLUTION AND HUMAN SOCIETIES - FROM SEDIMENTARY BASINS TO INDUSTRIAL LANDSCAPES, Session on "Urban and industrial socio-ecosystems: From past to present, and future"
Strasbourg, France • March 14-18, 2022
https://q13.sciencesconf.org

EUROPEAN GEOPHYSICAL UNION (EGU) GENERAL ASSEMBLY, Session on "Urban climate, urban biometeorology, and science tools for cities"
Online • April 3-8, 2022
https://meetingorganizer.copernicus.org/EGU22/session/42719

ASIA OCEANIA GEOSCIENCES SOCIETY (AOGS), Session on "Future of Cities within the Context of Climate Change"
Online • June 5-10, 2022
https://www.asiaoceania.org/aogs2022/

36TH PLEA CONFERENCE ON SUSTAINABLE ARCHITECTURE AND URBAN DESIGN
Santiago, Chile • November 23-25, 2022
https://www.plea2022.org/

INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC-11)
Sydney, Australia • August 2023
https://conference.unsw.edu.au/en/icuc11

Calls for Papers...

Special Issue on "Urban Microclimate and Air Quality as Drivers of Urban Design" in *Sustainability*. Abstract deadline: December 31, 2021
https://www.mdpi.com/journal/sustainability/special_issues/Urban_Microclimate_Air_Quality

Special Issue on "State-of-Art in Urban Climate Projections" in *Atmosphere*. Abstract deadline: February 5, 2022.
https://www.mdpi.com/journal/atmosphere/special_issues/Climate_Projections

Special Issue on "Advancement of Urban Heat Island Studies" in *Atmosphere*. Manuscript deadline: March 31, 2022.
https://www.mdpi.com/journal/atmosphere/special_issues/island_urban

Special issue on "Effects of the COVID-19 Pandemic on the Use and Perception of Urban Green Space "in *Land*. Abstract deadline: April 30, 2022
https://www.mdpi.com/journal/land/special_issues/pandemic_ugs

(...continued from page 1)

Ariane Middel from Arizona State University will be our next IAUC President, **Benjamin Bechtel** from Ruhr-Universität Bochum will be our next IAUC Secretary, and **Dev Niyogi** from The University of Texas will be our next IAUC Treasurer. Please join me in congratulating our newly-appointed colleagues and also in thanking them for their commitment to taking on these responsibilities for the next 4-year period, until August 2026. The Board believes that the future of IAUC will be in very good hands with this new Executive. The current executive will continue in their roles until August 2022.

Ariane Middel

Benjamin Bechtel

Dev Niyogi

Finally, please remember that the IAUC Board is very keen to receive proposals from the IAUC community for small regional meetings and summer schools. It is not too late to apply for support for later in calendar year 2022. Please see the IAUC website for details on how to apply for financial support for such activities.

Again, my best wishes for 2022.

– Nigel Tapper

IAUC Board Members & Terms

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- Melissa Hart (University of New South Wales, Australia), 2020-24
- Simone Kotthaus (Institut Pierre Simon Laplace, France), 2020-24
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- Dev Niyogi (Purdue University, USA): *ICUC10 Local Organizer*, 2016-2021
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- David Sailor (Arizona State University, USA), *Past Secretary* 2014-2018*
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- Helen Ward (University of Innsbruck, Austria), 2019-2022

* non-voting, ** non-voting appointed member

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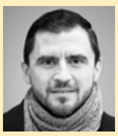
Urban Climate News – The Quarterly Newsletter of the International Association for Urban Climate

Editor: David Pearlmutter
davidp@bgu.ac.il

Urban Projects: Helen Ward
Helen.Ward@uibk.ac.at



News: Dragan Milosevic
dragan.milosevic@dgt.uns.ac.rs

Conferences: Joe McFadden
mcfadden@ucsb.edu

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, 2022 to the relevant editor.

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

Bibliography: Chenghao Wang and BibCom members
chenghao.wang@stanford.edu