Urban Climate News

Quarterly Newsletter of the IAUC

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From the IAUC President

Dear Urban Climate Community,

As spring arrives in the Northern Hemisphere, excitement is building for our flagship event: the **12th International Conference on Urban Climate (ICUC-12)**, which will be held **July 7–11, 2025**, in **Rotterdam, the Netherlands**. With close to **1000 abstract submissions**, the scale and diversity of topics reflect the growing momentum and engagement within our field. The local organizing team, led by **Marjolein van Esch** and **Gert-Jan Steenevelt**, has been working tirelessly to craft a diverse and engaging program, which will be released soon.

This is the **final newsletter before ICUC-12**, and I couldn't be more excited to reconnect with so many of you in person in July. The conference will also offer an **online format**, ensuring broad accessibility for our global community. Whether you plan to join us in Rotterdam or online, ICUC-12 promises to be an outstanding opportunity to share ideas, foster new collaborations, and celebrate the vibrant work advancing urban climate science.

12TH INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC-12)

Rotterdam, The Netherlands • July 7-11, 2025
http://icuc12.eu

Registration is now open at:
https://www.icuc12.eu/attend/register.html

The early bird deadline is May 29th at 13:00 CEST

Inside the May issue...

In this issue of *Urban Climate News*, we bring you another rich set of contributions from across our community. In our feature article, **TC Chakraborty** and colleagues discuss how discrepancies in global urban land datasets affect our ability to quantify climate risks. The urban projects showcase research on the Urban Heat Island over the Gangetic Plain in India (by **Pradhan Sarthi**) and discuss innovative retro-reflective surfaces to untrap radiation in cities (by **Xinjie Huang** and collaborators). **David Pearlmutter** shares a recap of urban climate activities at the AMS meeting in New Orleans, and the newsletter concludes with the latest ICUC-12 update from our local hosts!

As always, my sincere thanks go to David Pearlmutter and the **IAUC News and Bibliography Team**, as well as all contributors who make this newsletter possible.

See you in Rotterdam,

— Ariane Middel

President, International Association for Urban Climate
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'Full on Fight Club': How Trump is Crushing U.S. Climate Policy

President Trump has quickly transformed America's approach to the environment, withholding funds and stretching the limits of presidential power.

March 2025 — In a few short weeks, President Trump has severely damaged the government's ability to fight climate change, upending American environmental policy with moves that could have lasting implications for the country, and the planet.

With a flurry of actions that have stretched the limits of presidential power, Mr. Trump has gutted federal climate efforts, rolled back regulations aimed at limiting pollution and given a major boost to the fossil fuel industry.

He is abandoning efforts to reduce global warming, even as the world has reached record levels of heat that scientists say is driven largely by the burning of fossil fuels. Every corner of the world is now experiencing the effects of these rising temperatures in the form of deadlier hurricanes, floods, wildfires and droughts, as well as species extinction.

To achieve such a wholesale overhaul of the country's climate policies in such a short time, the Trump administration has reneged on federal grants, fired workers en masse and attacked longstanding environmental regulations.

All new presidents have their own agendas, but the speed and scale of Mr. Trump's efforts to uproot climate policy is unprecedented. "This is not the kind of stately tennis match of the usual switch-over in administrations," said Abigail Dillen, president of Earthjustice, an environmental law firm. "This is full on Fight Club." The Trump administration's moves have unfolded simultaneously across the sprawling government, affecting federal, state and local agencies and hitting government-funded projects in Africa, Antarctica and around the world. On Inauguration Day, Mr. Trump withdrew the United States from the Paris climate agreement, making it the only nation to walk away.

Mr. Trump has frozen funds appropriated by Congress for clean energy projects, taking particular aim at wind energy, the country's largest source of renewable power. He has stopped approvals for wind farms on public land and in federal waters and has threatened to block projects on private land. He has fired thousands of federal workers, dismantled programs aimed at helping polluted communities and scrubbed references to climate change from numerous federal websites. He has waged a multipronged assault at regulations designed to curb pollution, immediately sweeping some rules to the side and circumventing the normally lengthy rule-making processes. At the same time, Mr. Trump has declared an energy emergency, giving himself the authority to fast-track the construction of oil and gas projects as he works to stoke supply as well as demand for fossil fuels.

"We're going to drill, baby, drill and do all of the things that we wanted to," Mr. Trump said just hours after being sworn in for his second term.

The United States is producing more oil than any other nation in history, and is also the world's biggest exporter of

The Vineyard Wind Farm off the U.S. east coast in the Atlantic Ocean. Source: https://www.nytimes.com/2025/03/02/climate/trump-us-climate-policy-changes.html

natural gas. The fossil fuel industry donated more than $75 million to Mr. Trump's presidential campaign and Mr. Trump, in turn, promised to weaken environmental regulations in ways that would lower its costs and increase its margins.

The president has repeatedly mocked climate change, criticized regulations and said that more drilling would bring down energy bills. In several cases, the administration's actions have flouted the law, with agencies defying court orders, freezing funds in legally binding contracts and reinterpreting regulations to suit their aims. In doing so, Mr. Trump has busted through many of the barriers that were erected by the officials during the Biden administration who believed that process and the legal system would slow or deter him.

The administration and Republicans in Congress plan to use a legislative maneuver to quickly erase California's authority to ban the sale of new gasoline-powered cars in the state by 2035. That authority has never before been challenged in this way, and critics say the maneuver is illegal. But it would be much faster than trying to overturn the California ban through the standard process that requires months of public notice and comment.

Until last month, the United States was expected to record significant reductions in its greenhouse-gas emissions over the next decade. But the Trump administration's changes pave the way for more planet-warming pollution and will likely slow the advance of cleaner technologies like wind and solar energy. "To power the Great American comeback, President Trump is unleashing American energy and eliminating the Green New Scam," said Taylor Rogers, a White House spokesperson. "The Department of Energy and Environmental Protection Agency are working in tandem to implement President Trump's Day 1 executive action and undo Biden's radical climate policies that restrained America's economy and abundant natural resources."

Mr. Trump's supporters are delighting in the audacity and scale of his attacks on climate and environmental regulations. "They're doing all the things I thought they would do, and they're doing other things that I only dreamed they might do," said Myron Ebell, a conservative activist who led the E.P.A. transition team during Mr. Trump's first term.

Many of Mr. Trump's moves may have a lasting effect on the country's ability to confront climate change.

Thousands of federal jobs that are eliminated now may be hard to restore. Clean energy projects that were relying on federal funding may not proceed without the expected investments. A sudden stop to scientific work could create gaps in data collection that are impossible to fill. And environmental regulations that are stripped away could be difficult to revive.

Several of the administration's actions are already facing legal challenges. After Mr. Trump ordered federal agencies to pause billions of dollars in climate and energy grants that were authorized by the 2022 Inflation Reduction Act and the 2021 bipartisan infrastructure law, two federal judges ordered the Trump administration to let the money flow again.

In early February, one of those judges, Judge John J. McConnell Jr. in Rhode Island federal court, said the White House was defying his order by withholding funds. Some funds have begun moving, but many remain stalled.

John Podesta, a senior climate adviser in the Biden administration, called many of the Trump administration actions illegal. "We followed the law, and they're breaking the law," Mr. Podesta said. "It remains to be seen whether they'll be allowed to get away with it."

In the past few weeks Mr. Trump has fired thousands of employees at the Environmental Protection Agency, the Interior Department, the Department of Energy, and the National Oceanic and Atmospheric Administration, the government's premiere climate science agency. On Thursday, a federal judge said directives that led to mass firings were illegal. And in a move that could have far-reaching implications for government efforts to regulate industry, Lee Zeldin, the administrator of the E.P.A., has recommended that the agency reverse its 2009 finding that greenhouse gas emissions endanger human health and welfare, according to three people familiar with the decision. That would eliminate the legal basis for the government's climate laws, such as limits on pollution from automobiles and power plants.

"We're talking about undoing 50 years of environmental regulation and accelerating the extinction crisis and risking the health of the American people," said Ben Jealous, the executive director of the Sierra Club. "There's so much shocking news every day. People are struggling to process all of it."

Electric vehicles, long a target for Mr. Trump, have lost much of the federal support they gained during the Biden administration. Mr. Trump has directed Congress to eliminate federal subsidies for E.V.s., including tax credits for consumers, which could hurt the sales of Tesla, the electric car company, despite Elon Musk's central role in the Trump administration's cost-cutting efforts.

The Transportation secretary, Sean Duffy, signed an order to loosen fuel economy standards enacted by the Biden administration that were designed to encourage automakers to sell electric vehicles. And the administration moved to freeze $5 billion that Congress approved for the construction of a national network of electric-vehicle charging stations. The administration is also trying to stop states and even cities from enacting their own climate policies. Mr. Duffy recently lambasted what he called the "mismanagement" of California's high-speed-rail project, announcing an investigation into how the state was spending a $3.1 billion federal grant.

And the Transportation Department moved to revoke its approval of New York City's congestion pricing program, a plan designed to reduce traffic, raise money for public transportation and curb emissions. "The old paradigm was an administration will come in and do all the hard work of dismantling the old administration's policies and then replacing with its own," said Ms. Dillen. "This is a very different strategy, which is that we may not even bother to replace policies because we don't care about complying with the law."

Attempts to blunt the Inflation Reduction Act are already delaying projects. Jay Turner, a professor at Wellesley College who is tracking investments related to the law, found that at least 9 major projects worth $7.6 billion have been slowed in the past month as funding from the law has been put on hold and renewable energy companies adjust to the new reality.

Cleanup crews contracting with the E.P.A. in a neighborhood of Altadena, California, destroyed in the Eaton fire. Source: https://www.nytimes.com/2025/03/02/climate/trump-us-climate-policy-changes.html

"You've seen some real pullback," he said. "Established players in the industry are reassessing the market and how much capacity is needed right now, and you also see newcomers that suddenly don't see a path to bringing their projects to fruition."

Much of the damage to the country's environmental regulatory apparatus may be long-lasting. The E.P.A. said it would try to claw back about $20 billion that was awarded to eight organizations under the Greenhouse Gas Reduction Fund to help reduce greenhouse gas emissions in low-income communities. A top federal prosecutor resigned after she declined a request by the Trump administration to freeze the money, saying she did not have sufficient evidence to do so.

While the Energy Department has started releasing some grants for battery factories and electric grid upgrades, other projects remain on hold, according to several awardees. A $500 million program to upgrade hydroelectric dams around the country, for instance, remains frozen, and companies are halting construction or wondering if they will get reimbursed for work that has already been done.

On Wednesday, Trump said he believed Mr. Zeldin, the E.P.A. administrator, would be cutting about 65 percent of the agency's more than 17,000 jobs. Mr. Zeldin later said that he thought the E.PA. could cut at least 65 percent of its budget and make cuts to its work force.

The effective dissolution of the United States Agency for International Development has led to the immediate termination of long-running projects in the developing world aimed at helping vulnerable countries adapt to a hotter planet. And more sweeping actions may still be in store.

"The bigger changes are to come," Mr. Turner said. "What we've seen today has been fast, but it's just kind of the start of much more extensive efforts to dismantle the Biden administration's policies." —By DAVID GELLES, LISA FRIEDMAN and BRAD PLUMER *Source:* https://www.nytimes.com/2025/03/02/climate/trump-us-climate-policy-changes.html?unlocked_article_code=1.1U4.qo7j.wocCjEYel7qZ&smid=url-share

Water and climate: Rising risks for urban populations

March 2025 — Water is vital to a city's growth and stability and is the backbone to healthy societies. But the threat of too much or too little water puts everything at risk. This report highlights how the cities facing the worst climate impacts are often those with the highest social vulnerability.

Right now, 90% of climate disasters are water-related, and the 4.4 billion people who live in towns and cities – especially in low-income countries – are on the frontlines.

As the climate crisis continues to throw the water cycle out of balance, many of the world's largest cities are impacted in ways that are hard to anticipate and plan for. The frequency and magnitude of events such as floods and droughts are evolving due to climatic trends. And when water, sanitation and hygiene (WASH) services and systems cannot cope with intensifying and unpredictable climatic extremes, it is often the most vulnerable and marginalised people who suffer the worst impacts on their health, education and livelihoods, pushing them further into poverty.

This new research examines climatic trends over the past 42 years in the world's 100 most-populated cities, plus 12 cities where WaterAid works. It analyses whether these cities are becoming more prone to floods, or to droughts, and how these changes affect the people who live there.

Many cities experience "whiplash"; droughts that dry up water sources followed closely by floods that overwhelm infrastructure, destroying sanitation systems and contaminating drinking water.

Meanwhile, other cities are seeing dramatic climate reversals. Places accustomed to heavy rainfall are now facing droughts, while historically arid regions now grapple with unexpected floods. The research also examines how these changes intersect with social and infrastructural vulnerabilities to threaten people's access to safe and sustainable water, sanitation and hygiene services.

As two thirds of the global population are projected to live in cities by 2050, and climate hazards become more intense and erratic, there is an urgent need for decision makers to understand the threats to infrastructure and society, and to do much more to achieve and maintain universal and equitable access to WASH in cities.

Women line up to collect water from a water kiosk in Sylvia Masebo Community, Lusaka, Zambia. Source: wateraid.org

We call for:

- **Global leadership to accelerate action on water.** Governments and development partners must work through the existing multilateral platforms to deliver ambitious action on climate and water, including through the UNFCCC, the G7 Water Coalition and the G20 Call to Action on Strengthening Drinking Water, Sanitation, and Hygiene Services.
- **Greater investment to tackle the water crisis.** Development partners, multilateral banks and the private sector must work together to unlock investment in climate-resilient WASH systems that benefit the most vulnerable.
- **National government leadership to urgently deliver water plans.** Governments in affected countries must mainstream and implement WASH measures into their national and city-level climate adaptation plans with a focus on vulnerable groups, especially women and girls.
- **Prioritisation of the most vulnerable communities.** All decision-makers must urgently recognise overlapping vulnerabilities and prioritise the leadership and needs of women, girls and marginalised groups in climate-resilient WASH plans.

Trends in wetting (blue) and drying (orange) in 112 cities, 1982–2023. (Explore this interactive map)

More than 20% of cities are experiencing a reversal in climate extremes (Explore this interactive map)

Source: https://washmatters.wateraid.org/publications/rising-risks-urban-populations-water-climate-change

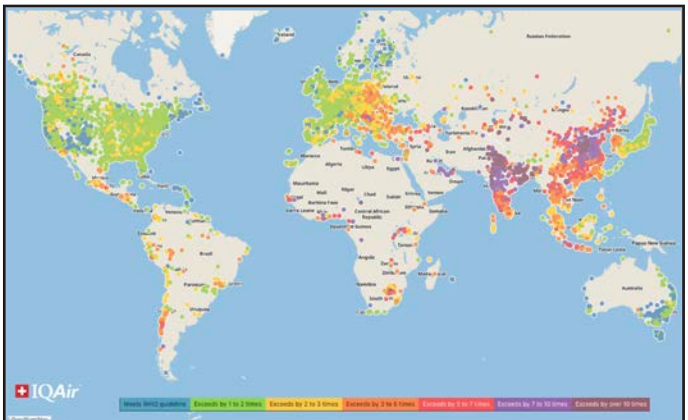
2024 IQ*Air* World Air Quality Report: Only 17% of cities breathe clean air

March 2025 — IQ*Air* announced the release of its 7th annual World Air Quality Report, highlighting alarming trends of the world's most polluted countries, territories, and regions in 2024. For this year's report, data from more than 40,000 air quality monitoring stations across 8,954 locations in 138 countries, territories, and regions were analyzed by IQAir's air quality scientists.

Key findings from the 2024 World Air Quality Report

- *Only 17% of global cities meet WHO air pollution guideline.*
- *Seven countries met the WHO annual average PM2.5 guideline of 5 μg/m^3: Australia, Bahamas, Barbados, Estonia, Grenada, Iceland, and New Zealand.*
- *The five most polluted countries in 2024 were:*
  - *Chad (91.8 μg/m^3): More than 18 times higher than the WHO PM2.5 annual guideline.*
  - *Bangladesh (78.0 μg/m^3): More than 15 times higher than the WHO PM2.5 annual guideline.*
  - *Pakistan (73.7 μg/m^3): More than 14 times higher than the WHO PM2.5 annual guideline.*
  - *Democratic Republic of the Congo (58.2 μg/m^3): More than 11 times higher than the WHO PM2.5 annual guideline.*
  - *India (50.6 μg/m^3): More than 10 times higher than the WHO PM2.5 annual guideline.*
- *A total of 126 (91.3%) out of 138 countries and regions exceeded the WHO annual PM2.5 guideline value of 5 μg/m^3.*
- *Byrnihat, India was the most polluted metropolitan area of 2024, with an annual average PM2.5 concentration of 128.2 μg/m^3. The region of Central & South Asia was home to the top seven most polluted cities in the world. India was home to six of the nine most polluted global cities.*
- *The most polluted major U.S. city was Los Angeles, California. Ontario, California was the most polluted city and Seattle, Washington was the cleanest major city in the U.S.*
- *Mayaguez, Puerto Rico was the cleanest metropolitan area of 2024, with an annual average PM2.5 concentration of 1.1 μg/m^3.*
- *PM2.5 concentrations decreased in every country in Southeast Asia, though transboundary haze and lingering El Niño conditions remain major factors.*
- *In Africa, the scarcity of real-time, publicly accessible air quality monitoring data is so severe that there is only one monitoring station for every 3.7 million people.*
- *Wildfires in the Amazon rainforest impacted vast areas of Latin America in 2024, with PM2.5 levels in some cities across Brazil's Rondônia and Acre states quadrupling in September.*
- *Oceania is the world's cleanest region, with 57% of regional cities meeting the WHO PM2.5 annual guideline value of 5 μg/m^3.*

There has been notable progress in expanding air quality monitoring across various countries, regions, and territories over the past 12 months. However, considerable gaps still exist in government-operated regulatory systems in many parts of the world. Low-cost air quality monitors—used by citizen scientists, researchers, community advocates, and local organizations—have proven to be effective tools to address these data gaps. These monitors have proven to enhance the availability of crucial data on air pollution levels worldwide.



Interactive global map of PM2.5 concentration by city

Source: https://www.iqair.com/gb/world-air-quality-report

"Air pollution remains a critical threat to both human health and environmental stability, yet vast populations remain unaware of their exposure levels," says Frank Hammes, Global CEO of IQAir. "Air quality data saves lives. It creates much needed awareness, informs policy decisions, guiding public health interventions, and empowers communities to take action to reduce air pollution and protect future generations."

IQAir's new Schools4Earth initiative acknowledges the outsized impact that schools have to expand the global air quality monitoring network and seeks to provide over 1 million schools with air quality monitors. IQAir estimates that currently only 21% of the world population has access to hyper-local, real-time air quality information. With a vision of every school worldwide monitoring air quality, IQAir estimates that over 94% of the global population would have access to real-time pollution data—filling critical information gaps and improving public health responses.

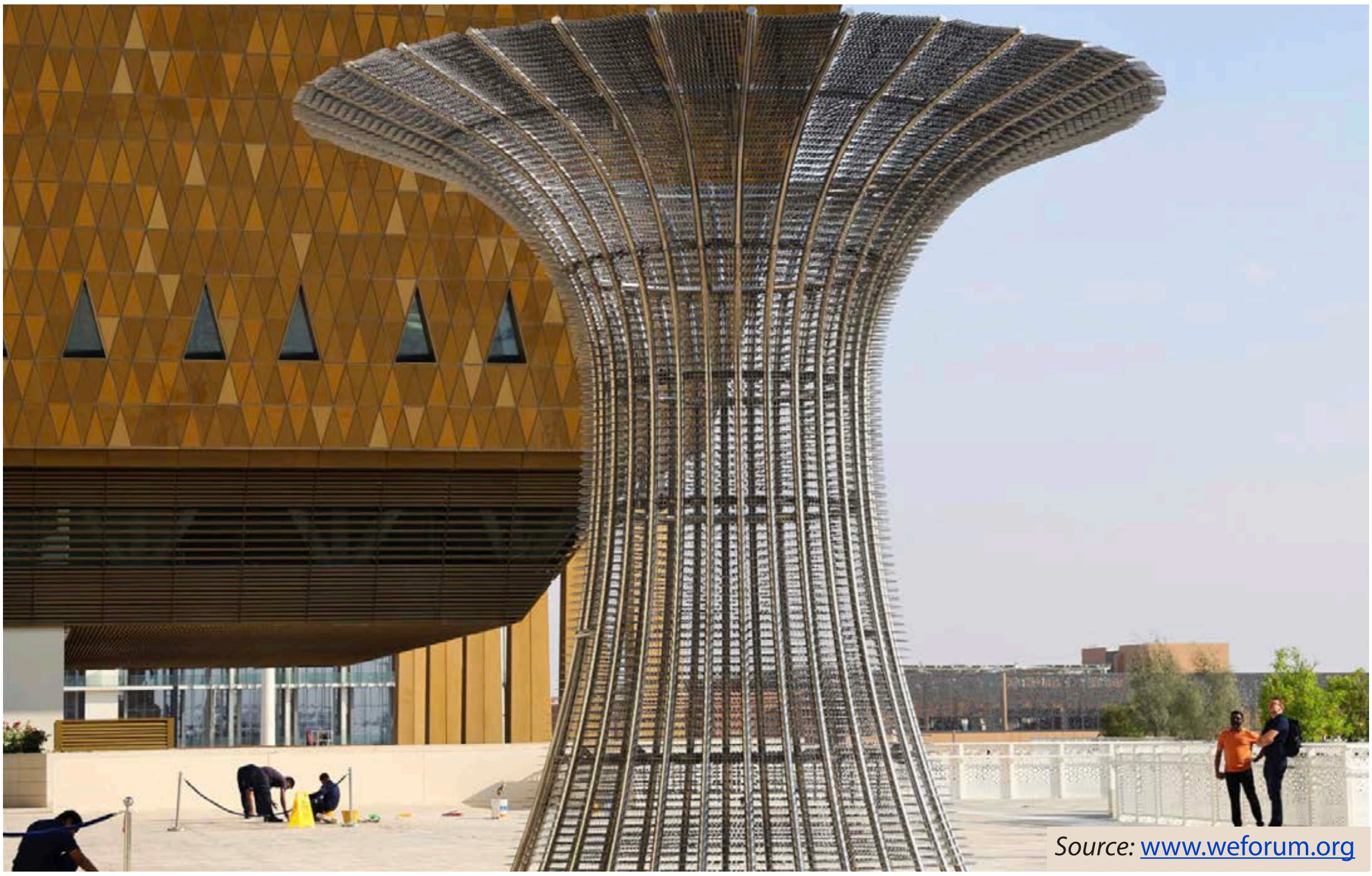
"Schools are at the center of communities, making them ideal locations for air quality monitoring. By outfitting schools worldwide with low-cost air quality monitors, over seven billion people would have access to hyper-local, real-time air quality data, creating a worldwide movement for cleaner air," says Hammes.

The World Air Quality Report underscores how this urgent, data-driven approach is crucial in driving policy changes and collective efforts to reduce pollution for future generations.

"The World Air Quality Report, which compiles measurements of air pollution from around the globe, should be a rallying call for urgent and concerted international efforts to cut pollutant emissions," states Aidan Farrow, Senior Air Quality Scientist with Greenpeace International. "By highlighting the disproportionate risk posed to young people by air pollution, the report reminds us that a failure to act today will be felt by future generations, while frequent references to human activities like coal burning and deforestation are a reminder that air quality, climate change, and the world that will be inherited by our children are inextricably linked."

Source: https://www.iqair.com/gb/newsroom/waqr-2024-pr

How we can unlock the potential of innovation districts?



Source: www.weforum.org

February 2025 — Cities today face mounting pressure to attract investment, talent and businesses, competing with others worldwide while fostering inclusive, sustainable economic growth. As traditional approaches to urban development evolve, innovation districts have emerged as a compelling model, serving as vital catalysts for economic regeneration and competitiveness.

While discussions about their role and effectiveness are longstanding, the challenge remains in understanding what truly makes an innovation district thrive and how its benefits can be scaled and equitably distributed.

What does the evidence tell us about the impact of innovation districts and how can other urban regions learn from their successes and challenges?

Three key forces shaping innovation districts

1. The growth imperative

Cities are constantly competing to attract investment while facing economic challenges and uncertainty. To drive growth, many are turning to place-based strategies, leading to various policy approaches.

In the United Kingdom, devolution allows regions more flexibility in funding and economic planning. South Korea, on the other hand, takes a more centralized approach, with cities competing for innovation investment. Meanwhile, private sector-driven initiatives – such as Ford's investment in Detroit – play a key role in shaping local economies in the United States.

Many national industrial strategies focus on technology, innovation and research as drivers of economic growth. But do these strategies genuinely benefit local communities?

Take Liverpool City Region and Cleveland Health Tech Corridor – thriving biomedical hubs with world-class expertise. Yet, surrounding communities still face significant health disparities. Ohio, for instance, ranks 47th in health outcomes according to the 2021 Health Value Dashboard, highlighting the gap between innovation and real local impact.

History offers important lessons. Today's conversations about inclusive innovation echo past debates, such as the urban regeneration efforts of the 1980s, which often relied on trickle-down economics.

London's Canary Wharf raised concerns about whether business-led development actually benefited local people, while 1990s science parks – designed as isolated, single-use spaces – missed opportunities for cross-sector collaboration. Today's innovation districts must do better by prioritizing connectivity, inclusivity and adaptability.

2. Long-term sustainability and resilience needs

Building the right thing in the right place is more crucial than ever. As cities commit to net zero targets, the hefty carbon cost of urban development must be reconciled with the need to grow.

With the built environment accounting for 40% of global carbon emissions, the traditional speculative, office-space development model struggles to deliver long-term value and local benefit to justify the high embodied carbon costs. Illustrative of broader trends, in the second quarter of 2024, the share of empty US office space reached a historic high of 20.1%.

Post-pandemic, we should reconsider the long-term value and adaptability of places and not reflexively assume that redevelopment from scratch is the answer. Instead, we must leverage existing assets and balance growth objectives with the carbon implications of building afresh.

3. Digital infrastructure and industry 4.0

Our increased reliance on technology and the ubiquity of digital services has fundamentally changed economic participation and our experience of place. If places cannot adapt to these expectations, they risk being left behind.

Digital infrastructure is essential for economic engagement and not only for a new generation of knowledge and digital economy workers but also for public and urban service interaction. Ride-sharing services such as Uber have revitalized night-time economies while introducing transportation challenges. E-commerce has disrupted high streets, contributing to congestion and upending urban logistics. Remote working has dampened office space demand, compelling cities to rethink inner core usage. These shifts highlight the growing influence of digital realities on urban and economic planning.

Moreover, innovation districts must prioritize robust digital infrastructure to support high-potential tech businesses and the technologies they develop. Testbeds are increasingly essential innovation district components, whether for testing robotics renewable energy technology, such as in Masdar City, UAE, or autonomous vehicles, such as the Jurong Innovation District, Singapore.

Together, these three drivers redefine how innovation districts can serve cities as models for place-based economic growth.Public dialogue on innovation districts has traditionally looked at the characteristics of their successes, including leadership, critical mass and coordination. Building on research, we now have an opportunity to review global evidence and hear from innovation district pioneers about their impact and how the lessons they have learned can translate to other geographies.

Our goal is to uncover tangible and practical actions in innovation districts that have demonstrably revitalized urban areas and catalyzed growth. We seek evidence of effective urban economic policies and their interaction with the built environment and placemaking to create successful innovation districts.

- *Innovation districts must balance economic growth with local benefits.*
- *Sustainability and adaptability are critical for the long-term success of innovation districts.*
- *Digital infrastructure is shaping the future of urban economies.*

2025 Innovation Strategy Dialogue series

The World Economic Forum's Alliance for Urban Innovation will examine these drivers of change in its 2025 Innovation Dialogue series, bringing together perspectives from innovation districts worldwide and industry partners in three collaborative workshops. Each will explore the components of innovation districts, considering their social, environmental and economic sustainability through:

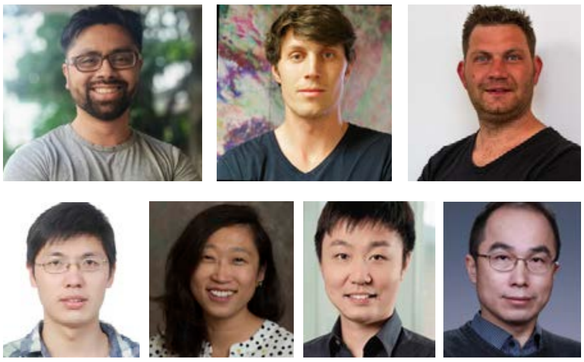
Governance and collaboration frameworks: How do innovation districts start and how are they sustained? Who is involved? Can we define the characteristics of governance that encourage place-based collaboration and deliver equitable and self-sustaining innovation?

Placemaking and master planning for innovation: How do we transform physical places to catalyze innovation? How can we plan and design vibrant, inclusive and flexible spaces to support innovation?

Digital infrastructure to support growth: How can we develop digital infrastructure that supports and accelerates innovation, economic growth and social value? What future role will data and connectivity play in a successful innovation district?

An Innovation District Toolkit will be published by the end of 2025, drawing on the best case studies and place-based innovation experts from government, the private sector and academia. Various actors will use it to help establish the next generation of innovation districts. We are aiming for practicality, accessibility and a strong dose of inspiration. If you have a case study or want to be involved in the Innovation Dialogue series, please contact Jibran Ahmed (jibran.ahmed@weforum.org). *Source:* https://www.weforum.org/stories/2025/02/how-we-can-unlock-the-potential-of-innovation-districts/

Large Discrepancies in Urban Land Estimates from Global Datasets Lead to Uncertainties in Quantifying Climate Risks



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This report is based on the following paper: Chakraborty, T., Venter, Z. S., Demuzere, M., Zhan, W., Gao, J., Zhao, L., & Qian, Y. (2024). Large disagreements in estimates of urban land across scales and their implications. *Nature Communications*, 15(1), 9165. https://doi.org/10.1038/s41467-024-52241-5

Background

Global spatially continuous estimates of urban land have various use cases for science and applications, from isolating environmental and climate risks to urban residents to providing surface constraints for weather and climate simulations to informing urban planning priorities. The explosion in satellite observations, growth in computational power, and various methodological advancements have all enabled the development of an increasing number of global urban land cover datasets in the last decade. Of note, the availability of over 30 years of imagery from the Landsat mission (Wulder et al., 2022) has led to several estimates of urban land that span decades. More recently, 10 m resolution imagery from the Sentinel-2 mission (Bertini et al., 2012) have been used as input to generate several land cover products, most with an urban class, at this high resolution (Venter et al., 2022). Given the variability in methodology, input data, and operational definition of urban, one would expect some differences between these products. Older generation products had similar differences in estimates of urban extent (Potere et al., 2009). However, a comprehensive comparison covering this ever-growing list of current-generation urban products was missing. While new dataset development is generally accompanied by some accuracy assessment against existing products, these are limited in scope, usually to the remote sensing literature, and not intended to compare product typologies. More importantly, since many common use cases of these urban land estimates do not simultaneously consider multiple products due to a combination of legacy and convenience, it is important to understand the implications of using one product over another for various common applications.

Analyzing disagreements in global estimates of urban land across scales

In a recent paper (Chakraborty et al., 2024), we analyze urbanization patterns across spatiotemporal scales from several such widely used current-generation datasets. The datasets considered include thirteen satellite-derived land cover data, two surface datasets used in weather and climate models, and four future projections of urban land. We find substantial disagreements in percentage of urban land from these datasets. These differences are seen across spatiotemporal scales, from variability in urban percentage from grid to continent to country scale (Fig. 1a), to discrepancies in estimates of urban growth over time (Fig. 1b).

These disagreements are frequently the result of differing urban definitions. Of note, the newer datasets at higher resolution (10 m) can partially resolve urban features like vegetation, roads, and buildings. However, the differences in the definition of urban become prominent at these resolutions, leading to the greatest inter-product spread in estimates of urban land for more recent years (Fig. 1b). For instance, Google's Dynamic World (Brown et al., 2022) includes urban vegetation in, what they call, the "Built Area" class. On the other hand, the European Space Agency (ESA) WorldCover (Zanaga et al., 2021) product explicitly excludes urban vegetation from its "Built-up" class. Similarly, the World Settlement Footprint 2019 (Marconcini et al., 2021) is focused on human settlements and excludes roads from the dataset. Similar differences in definition, such as the use of a 30% imperviousness threshold in the "Urban and Built-up Lands" class of the Moderate Resolution Imaging Spectroradiometer (MODIS) land cover product (Sulla-

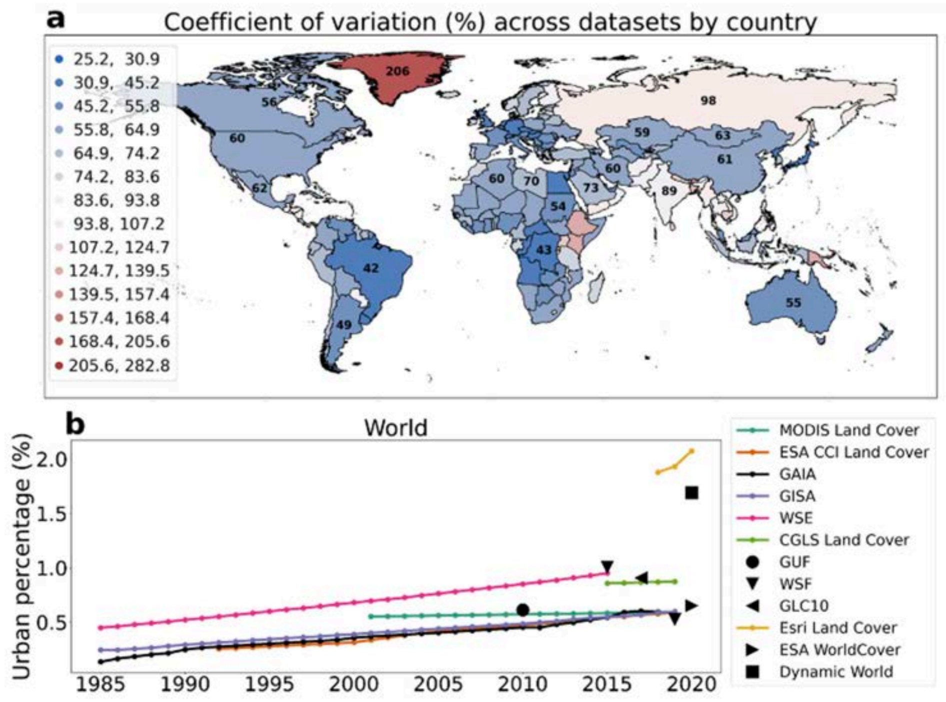

Figure 1. a) Coefficient of variation (standard deviation divided by mean) among eight global estimates of urban land by country. b) Urban percentage from twelve global data products for the world, with long-term changes shown for datasets spanning multiple successive years.

Menashe & Friedl, 2018), lead to differences in estimates of historical urbanization.

We also discuss other reasons for these inconsistencies, including the methodologies used for product development, the minimum mapping units, the input data, etc. Despite these inconsistencies, the datasets agree that we live in a rapidly urbanizing world, with global urban land nearly tripling between 1985 and 2015 (Fig. 1b).

Implications of these disagreements across potential use cases

We also examine the implications of these inconsistencies for several use cases, including for monitoring urban climate impacts, such as localized urban warming and urban flood risks, and for modeling the influence of urbanization on weather and climate from regional to global scales. We show that the choice of product to delineate urban land among 8 present-day (circa 2019/2020) estimates can influence the calculated surface urban heat island intensity (Fig. 2a), with even the sign of the signal not being consistent for urban clusters in arid climate during northern hemisphere summer (June, July, August) and in polar climate for northern hemisphere winter (December, January, February). Similarly, when examining urban growth in flood prone areas between 1985 and 2015, almost an order of magnitude difference can be seen between some products (Fig. 2b).

We also discuss the potential implications of using these land cover products for weather and climate modeling. As an example, we show that the urban surface dataset used in several global and some regional climate models (Jackson et al., 2010) significantly overestimates urban land for Asia and Africa and underestimates it for North America (Fig. 3a). This is because, in addition to being somewhat outdated, this dataset is from population density estimates, thus related to demographic urbanization, not physical urbanization, the two being highly decoupled in developing regions. This can lead to biases in model outputs because the biophysical properties prescribed for urban land in these models, and which strongly modulates the surface energy budget, relate primarily to the physical changes due to urbanization. Similarly, we compare four different future urban projections across continents and Shared Socioeconomic Pathways (SSPs). Not only are there large differences in end-of-century urban percentage across datasets, the pattern of growth can also vary (Fig. 3b), all of which depend on population projection constraints, subregions of analysis, and historical data used for calibrating these datasets. With recent efforts to include future urbanization in models, this comparison underscores the importance of considering multiple datasets to provide more robust uncertainty estimates for urban-resolving climate projections, which can more appropriately inform urban climate mitigation and adaptation strategies in a rapidly urbanizing world.

Summary and Future Steps

This study compares several global urban datasets, assessing how discrepancies among them can impact various applications, from land cover projections to weather and climate modeling to quantification of urban

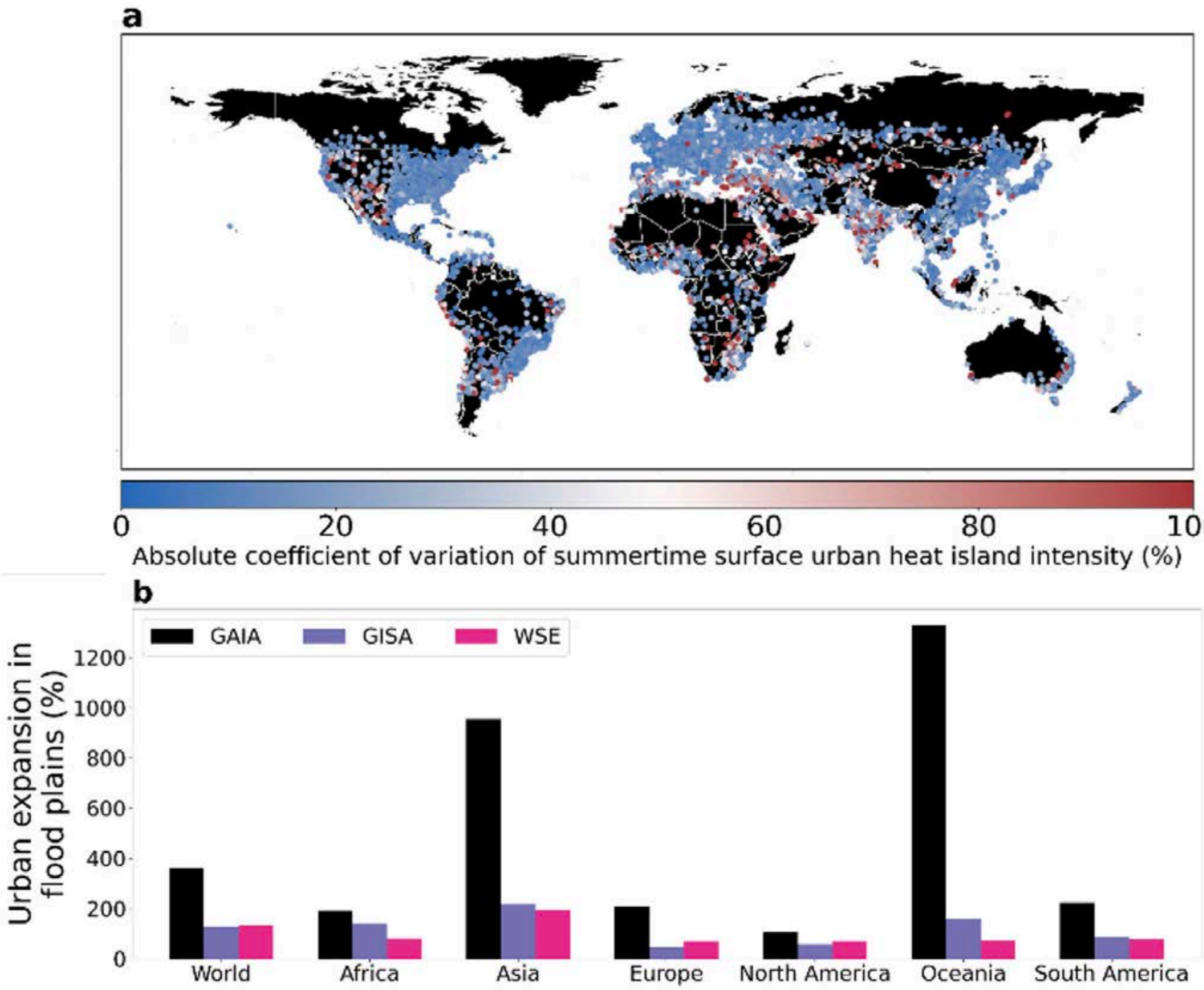

Figure 2. a) Absolute coefficient of variation (based on eight urban land cover datasets) in the calculated surface urban heat island intensity during the summer months of 2018–2022 for approximately 10,000 global urban clusters. b) Estimated changes in urban land within flood plains globally and across all continents between 1985 and 2015 based on three long-term urban datasets.

environmental hazards. Large disagreements are found across different global datasets, with larger divergences between products seen in more recent years. More importantly, our results demonstrate the importance of choosing application-appropriate datasets for examining specific aspects of historical, present, and future urbanization with potential implications for informing sustainable development, resource allocation, and quantifying climate impacts. Although our analysis here is limited to a few case studies, similar disagreements in magnitude of urban climate signal stemming from choice of land cover data has been found in other recent studies (Chakraborty & Qian, 2024; Liu et al., 2024). For surface inputs to weather and climate models, we suggest choosing land cover datasets that are consistent with the structural assumptions about urbanization in the corresponding models. For instance, another ongoing project involves combining the ESA WorldCover product with building footprint estimates to generate facet-level urban biophysical properties for urban canopy models (Cheng et al., 2024). Urban planners and policymakers are generally encouraged to use region-specific maps rather than global datasets, when possible, as these are better calibrated to local conditions through more refined training and validation. Since the preprocessing methods and urban definitions vary between datasets, the fit-for-purpose datasets for specific applications should be determined on a case-by-case basis with guidance from relevant domain experts. Overall, our study emphasizes the need for transparency about the underlying assumptions made when developing and using datasets to better inform policy and decision-making and calls for a sustained effort within the urban scientific community to evaluate

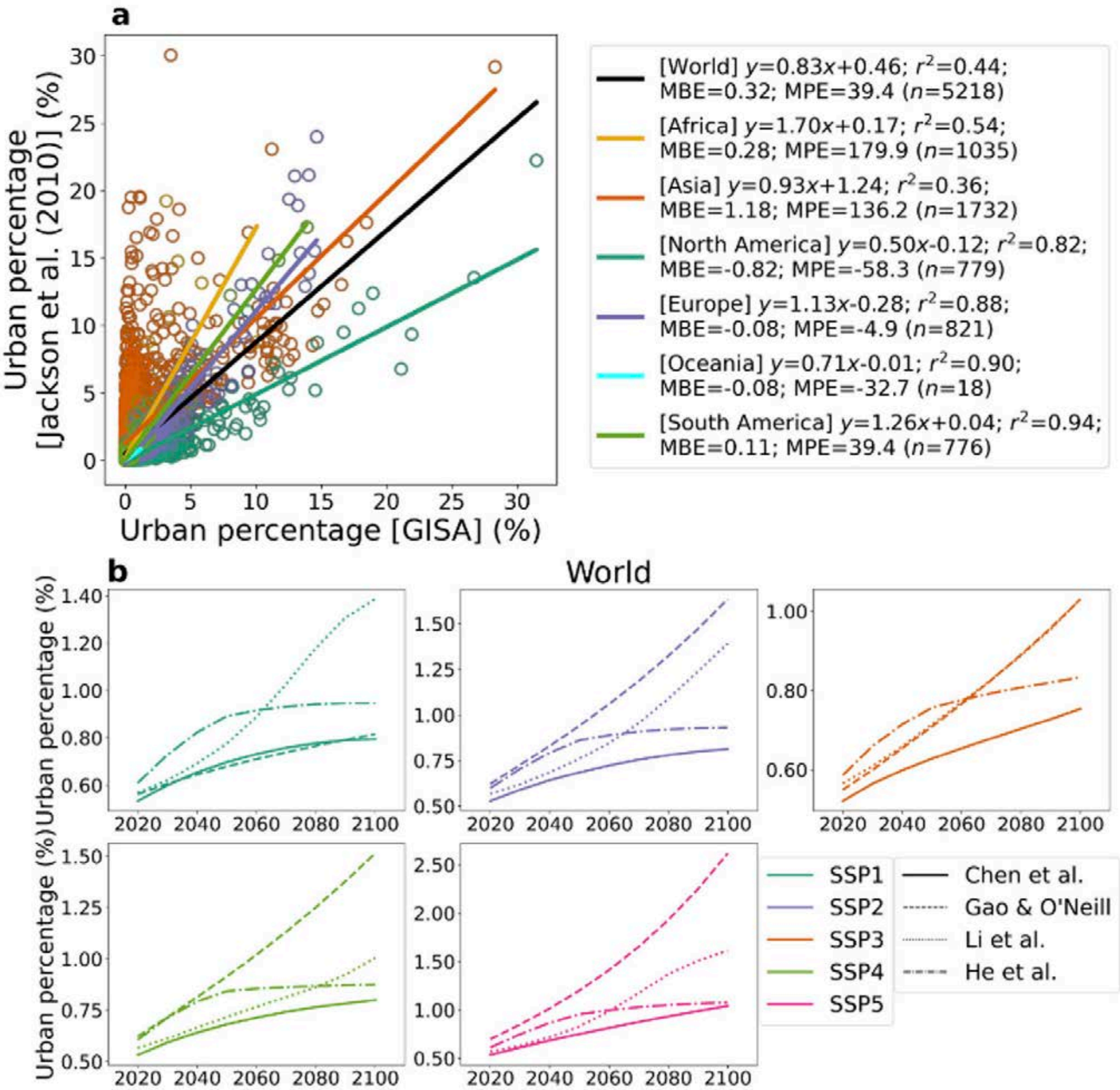

Figure 3. a) Linear regressions comparing grid-wise urban percentages from the GISA dataset for 2001 with the total urban percentages from the medium-density, high-density, and tall-building district classes of the Jackson et al. (2010) dataset, analyzed globally and for each continent. For each case, the line of best fit, coefficient of determination (r^2), mean bias error (MBE), mean percentage error (MPE), and sample size (*n*) are noted. b) Projected percentage of global urban area from 2020 to 2100 across various Shared Socioeconomic Pathways (SSPs), based on multiple kilometer-scale estimates.

and adopt suitable datasets for distinct research and policy applications

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A ray of sun peeks through the clouds over Piazza d'Italia in New Orleans, Louisiana. NOLA recently hosted the 105th AMS annual meeting, where urban climate took center stage in more ways than one (see page 17).

Urban Heat Island over the Gangetic Plain of India

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Introduction

The Urban Heat Island (UHI) phenomenon is first introduced by Howard (1833). The UHI is formed when a town or city shows comparatively warmer temperatures than nearby rural areas. In general, the cause is the fast urbanization or industrialisation in urban area resulting in the increment of concrete jungle, thus altering the thermal properties. The difference in air or surface temperature between urban and rural areas normally measures the intensity of UHI. The UHI is categorised (Voogt and Oke, 2003; Lockoshchenko, 2015; Bahi et al, 2016) under three groups, namely (i) Atmospheric UHI (AUHI), which is further divided into two subgroups, Urban Canopy Layer UHI and Urban Boundary Layer UHI, (ii) Underground UHI (UUHI) and (iii) Surface Urban Heat Island (SUHI). To quantify the UHI, the Land Surface Temperature (LST) based approach or the SUHI approach is widely used (Meng and Liu, 2013; Rao, 1972; Bahi et al, 2016; Shashtri et al., 2017; Kumar et al, 2017; Sultana and Satyanarayana, 2018). The LST is influenced by several factors like soil temperature, vegetation canopy, vegetation body, surface albedo, and moisture content. In fact, the most important effect of unplanned urbanization is the change in LST and consequently the formation of UHI (Ding and Shi, 2013) and difference in LST is an indicator of SUHI Intensity (SUHII). It is known that LST highly depends on Land Use Land Cover Changes (LULCC) (Xian, 2008). The horizontal profile of LST (relatively greater temperature over urban than its rural surroundings) decides the extent and intensity of SUHI. The formation of SUHI is more prominent during night time when nocturnal cooling is more over rural areas and therefore the intensity of SUHI is seen during night time, especially after sunset. The surface undergoes nocturnal irradiative cooling, and thus retarding the rate of decrease in air temperature, whereas in rural areas nocturnal cooling occurs more rapidly (Lee and Baik, 2010). This difference in surface energy balance causes a marked difference between urban and rural LST, resulting in formation of SUHI. The SUHII varies with morphology and size of the city (Oke, 1973; Sakakibara and Matsui, 2005; Hoffmann et al., 2012). Decrease in Urban Greens can intensify the SUHII while increase in greenery can mitigate its impact (Chen et al., 2014). SUHI may trigger heat related illness, affect urban air quality (Qi et al., 2007), induce heat waves (Holderness et al., 2013) and adversely affect local climate (Van Weverberg et al., 2008; Sarkar and Ridder, 2011).

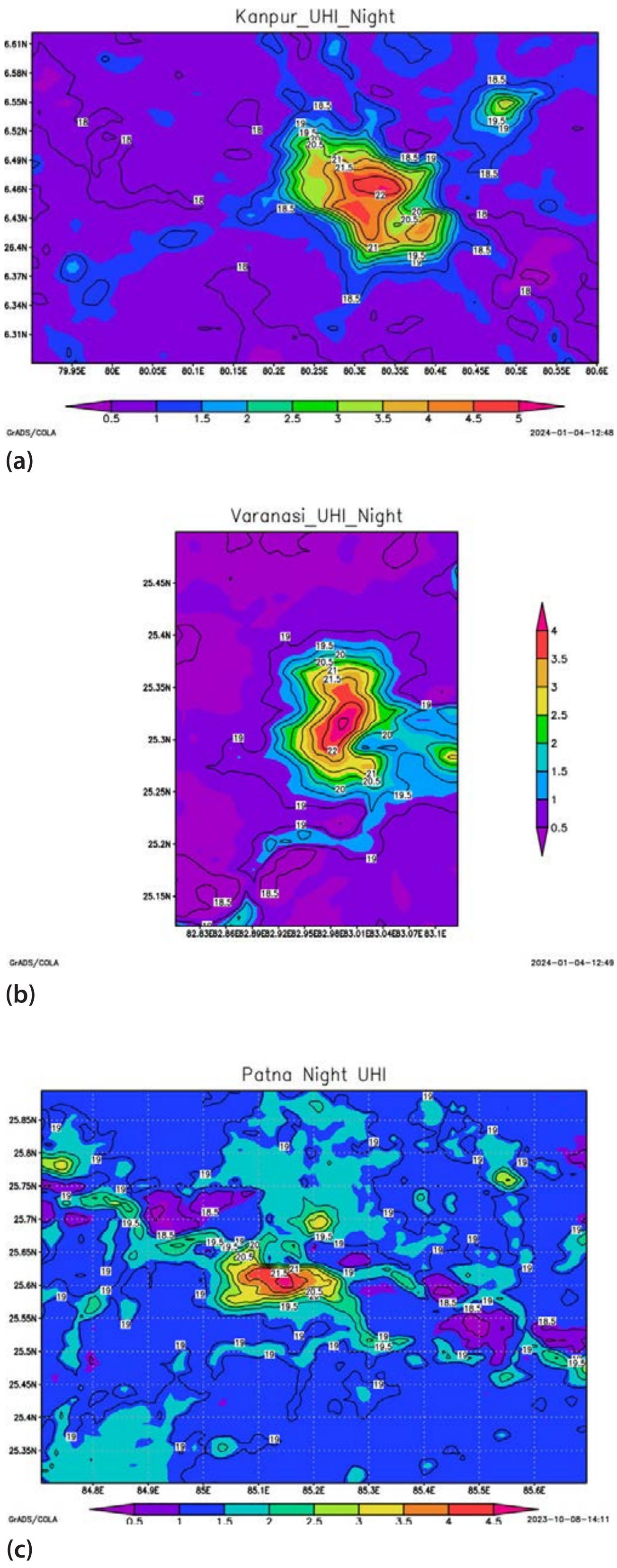

Figure 1. Spatial distribution of SUHII over (a) Kanpur, (b) Varanasi and (c) Patna.

Study area, data and methodology

Study area

The study area is comprised of towns/cities along the Gangetic plain of India. These town/cities are Patna, Varanasi, and Kanpur, categorized as densely populated, holy city and city with lot of industry, respectively. The river Ganga flows transversely from west to east, and these are spread over north and south of the Ganga.

Data and Methods

The Night-time LST data of Terra-MODIS (Moderate Resolution Imaging Spectro radiometer) Land Surface Temperature (Collection 6.1) on monthly basis from MOD11A2.061 (temporally upscaled from native 8-day product) at spatial Resolution of 1km x 1km for the period of 2001-2020 is considered. The data is mapped on the city extents based on the MODIS-Combined IGBP Land Cover Product (MCD12Q1), further the representative urban pixels is determined using the LCZ product (Demuzere et al. 2022), covering all the available urban representatives.

The trend analysis is performed on the extracted data using the Mann-Kendall Test on MiniTab® software. Mann-Kendall test is a non-parametric statistical test applied to check the possibility of significant trend in the data and is used in various climate studies (Ezber et al. 2007; Kumar et al. 2010). The MK Test evaluates the null hypothesis (H_0) of no significant trend against the alternative hypothesis (H_a) for the presence of any possible significant increasing or decreasing trend.

The MK test statistic is defined for *N* number of data points as follows:

$$MK\ Test\ Statistic(S) = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} sgn(x_i - x_j)$$

where:

$$sgn(x_j - x_i) = 1 \text{ if } (x_j - x_i) > 0$$
$$= 0 \text{ if } (x_j - x_i) = 0$$
$$= -1 \text{ if } (x_j - x_i) < 0$$

Sen's Slope estimator (β) (Sen, 1968) has also been applied on the data over present study area. This value is used for visualising the magnitude of the trend, where:

$$\beta = median\left(\frac{x_i - x_j}{i - j}\right), \forall j < i$$

in which 1<j<i<n.

Results and discussion

The maximum intensity of UHI of 4-5 degrees C is noticed over Kanpur and Patna. The city of Kanpur has a lot of industry while Patna is densely populated.

To know the trend in the intensity of SUHI, the Mann-Kendal test is applied for the period of 2001-2020 and the annual trend of intensity of SUHI is shown (Table 1). An upward trend over all considered cities and towns is noticed with an increasing Sen's Slope Value.

Fig. 1 shows a prominent presence of a thermal island over each of the considered stations. While it is more interesting to say that the Kanpur and Varanasi are more like a concentrated stand-alone case of heat island, whereas Patna is developing into a heat archipelago with milder intensity heat islands and corridors across the city periphery. The data for top two stations (Kanpur and Patna) is then subjected to a seasonal analysis (Fig. 2a,c), to envisage the variability of the SUHII across the seasons. It is found that the Post-Monsoon season is most vulnerable in Kanpur while the winter season is showing highest SUHII over Patna. Except monsoons all the seasons exhibit a considerable inclined time-series which represents an increase in the intensity of SUHI.

Table 1: Statistical test results for the selected cities

Stations	Mann-Kendal Trend (2001-2020)	Sen Slope (2001-2020)
Kanpur	Upward	0.032
Varanasi	Upward	0.029
Patna	Upward	0.053

Conclusions

The maximum intensity of UHI of 4-5 degree are noticed over Kanpur and Patna in the night-time data. The MK test and Sen's Slope estimator also indicated an increasing trend of SUHII over the selected stations. While the Kanpur has recorded the maximum spatial SUHII; the Patna SUHII is more of a heat archipelago type. The seasonal analysis also reveals that the SUHII is not only increasing in the long term datasets but also is increasing almost across all the seasons. These findings opine for strict measures like increase in greenery to mitigate effects of UHI in an urgent basis.

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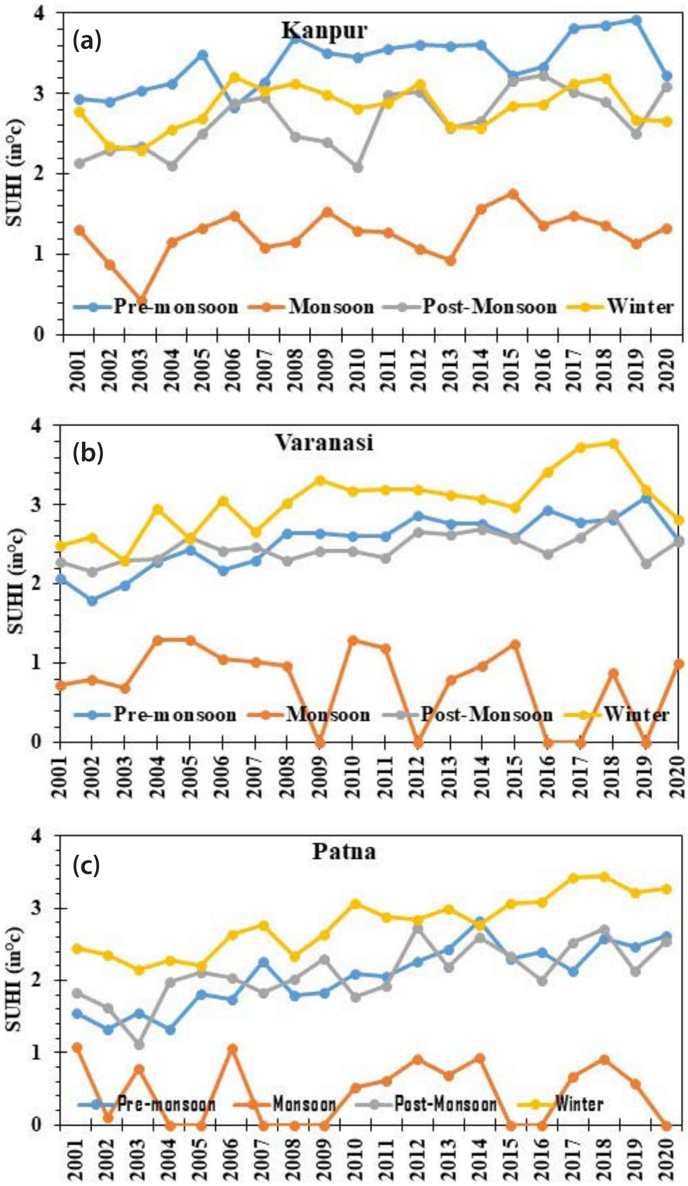

Figure 2. Seasonal time-series for the city of (a) Kanpur, (b) Varanasi and (c) Patna.

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Retro-reflective surface to untrap radiation in cities

This work summarizes the recent publication: Huang, X., Bou-Zeid, E., Pigliautile, I., Pisello, A. L., & Mandal, J. (2024). Optimizing retro-reflective surfaces to untrap radiation and cool cities. *Nature Cities*, 1(4), 275–285. https://doi.org/10.1038/s44284-024-00047-3.

Introduction

Cities continue to lie at the intersection of two heat hazards: the temporal temperature peaks that occur during heatwaves and that will worsen in a warming climate, and the spatial heat islands that often make cities several degrees hotter than their immediate surroundings (Li & Bou-Zeid, 2013). The physical basis and manifestation of this problem have been abundantly researched and are rather well understood. A lingering question, however, is what to do about it, and how to adapt cities to these heat risks. Highly-reflective (HR) surfaces, also known as reflective/cool/high-albedo surfaces, are some of the most extensively studied urban cooling strategies and are a promising and increasingly adopted approach for roofs (Li et al., 2014; Santamouris, 2014; Sen & Khazanovich, 2021). As shown in the contrasting schematics of regular (Fig. 1a) and HR (Fig. 1b) surfaces, HR roofs feature a high solar reflectance (albedo) that can raise the fraction of incident sunlight returned to outer space, thus reducing what gets absorbed by building surfaces. However, while proven to be generally beneficial especially in roof applications in hot low-rise low-density urban areas, façade and ground application of HR surfaces pose multiple problems including glare and intense diffuse reflection of energy onto neighboring buildings, pavements, and pedestrians. This can aggravate pedestrian-level thermal stress (Pigliautile et al., 2020; Huang et al., 2022). In addition, roof cooling by HR surfaces is useful at the city scales, but may have only indirect and potentially weak influence on street-level and canyon conditions (Yang & Bou-Zeid, 2019), which are most relevant for health and livability outcomes.

An alternative to cool the canyon air and pedestrians therein are retroreflective (RR) surfaces, which can reflect a fraction of the incoming sunlight directly back to its source (ideally) or at least upwards (imperfectly) (Fig. 1c). RR solutions thus have great potential to overcome some of the disadvantages of HR surfaces and provide additional cooling benefits. RR materials are widely used in the transportation industry with a relatively mature manufacturing technology. Recent studies are exploring the appealing potential of using RR materials on building facets, with a wide range of cooling effects reported: 3 to 36% of urban reflectivity increases, –0.4 to –25°C of urban surface temperature reduction, and –2.4 to –7.7°C of indoor air temperature reduction (Wang et al., 2021). The effectiveness of these RR benefits depends strongly on material types, surface selection, local climate and weather conditions, street geometries and orientations, among others. Thus, it is imperative to comprehensively

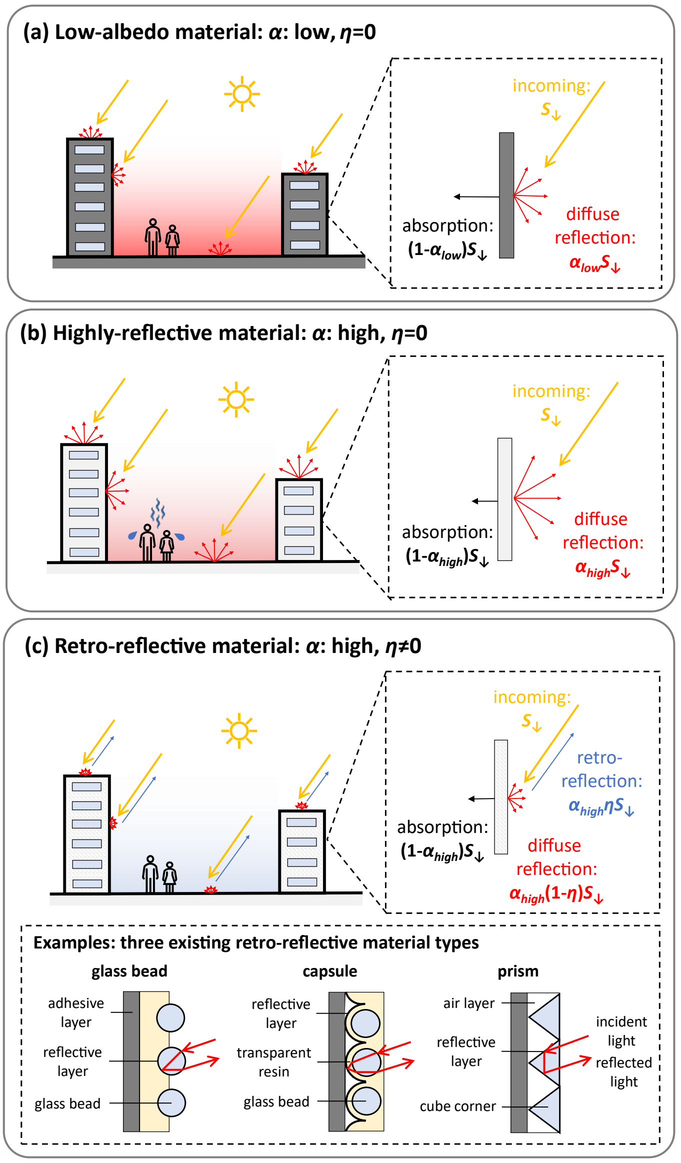

Figure 1. Schematics of normal (low-albedo, top panel), highly-reflective (second panel), and retro-reflective (third panel) surfaces in urban environments. Three examples of existing retro-reflective material types (bottom panel). $SW\downarrow$**: downwelling shortwave radiation;** α**: total reflectivity, i.e., albedo;** η**: retro-reflectivity.**

evaluate RR cooling performance across the whole parameter space, as well as to link the benefits more directly to human thermal comfort. This would then allow an optimized design strategy, which will be essential to ensure broader applicability and efficient implementation of this promising urban cooling technique.

To bridge the aforementioned gaps, we developed a new RR module and embedded it in a comprehensive urban canopy model (UCM) developed at Princeton University (PUCM). With the PUCM-RR model, we first conduct a local evaluation of the impacts of RR walls and pavements on urban heat abatement and human thermal comfort improvement, with a particular focus on investigating the significance of two key optical properties — total and retro-reflectivity — for common RR material types. Next, we investigate the optimal implementation strategy of RR by testing different latitudes, seasons, street geometries and orientations, considering both solar radiation exposure levels across various geographic regions and solar radiation distribution schemes in diverse street configurations. Through these approaches, we develop globally informative design guidelines for RR surfaces tailored to localized conditions, which can facilitate effective implementation of RR solutions to address the widespread urban overheating problem.

Methods

Representing retro-reflectivity in an urban canopy model

UCMs are a very broadly used urban land surface modeling framework in urban climate applications: they have been extensively applied to simulate urban surface energy fluxes and meteorology at local, regional, and global scales (Grimmond et al., 2010, 2011; Oleson & Feddema, 2020; Lipson et al., 2023). Specifically, the UCM used in this study was developed at Princeton University (PUCM) (Wang et al., 2013; Sun et al., 2013; Li & Bou-Zeid, 2014; Ramamurthy et al., 2014; Ryu et al., 2016). The PUCM represents a generic infinitely-long (in practice this simply means its length is ≫ its height) 2-D street canyon as the basic urban surface unit, which consists of a roof, two facing walls, and a ground surface. It has been successfully validated under various climates, demonstrating good predictive capabilities along with high computational efficiency. In addition, a human thermal comfort model has been recently coupled into PUCM: it dynamically resolves radiative, convective, conductive, and evaporative heat exchanges between a pedestrian and their surrounding urban environment to more realistically represent human-level heat stress (Pigliautile et al., 2020).

Based on the PUCM, we developed a new radiation module that incorporates the effects of RR materials on the existing two-reflection radiation framework. In the previous PUCM, we solved radiative energy distribution and redistribution by considering two reflections between urban facets, assuming all urban surfaces to be Lambertian, i.e., with isotropic scattering and reflection (see Fig. 1a). To parametrize the retroreflective feature, we need to incorporate and modify two important optical properties: total reflectivity and retro-reflectivity. The total reflectivity (α), also known as albedo, represents the ratio of reflected solar radiation to the total incoming solar radiation. The retro-reflectivity (η) represents the ratio of radiation reflected back, at around the same incident angle, to the total reflected radiation, while the other fraction of radiation is assumed to be perfectly diffusely reflected. With a total incoming solar radiation of $S{\downarrow}$, a RR surface will absorb $(1-\alpha)S{\downarrow}$, retro-reflect $\alpha\eta S{\downarrow}$, and diffusively reflect $\alpha(1-\eta)S{\downarrow}$ (see Fig. 1c for schematic illustration). Detailed equations for modified shortwave radiation budgets can be found in the Methods part of the original publication (Huang et al., 2024).

Numerical experiment design

The PUCM was driven by meteorological forcing data measured by a rooftop eddy-covariance tower during 2010-2011 on the Princeton University Campus in Princeton, NJ, USA (Wang et al., 2013; Sun et al., 2013). The simulation was conducted to explore the hottest day (July 7th, 2010) during the one-year meteorological measurement, with a three-day spin-up period to provide realistic initial conditions and allow the walls and grounds to equilibrate. The meteorological conditions are generally representative of extreme hot conditions with high air temperature, high air humidity, and low wind speed. The shortwave radiation forcing shows fluctuations during the tested day due to intermittent clouds. Thus, in the simulation, we adopted an ideal clear-sky diurnal profile of solar radiation mainly based on Julian day and solar zenith angles (Daneshyar, 1978) to more clearly observe the maximum cooling performance of RR surfaces by removing the confounding cloud impacts. To evaluate cooling benefits of RR material compared with normal material, we first set up a baseline scenario with normal (Lambertian) walls and ground with their typical albedos (0.25 and 0.15, respectively). Other model input parameters, e.g., latitude, canyon dimension, canyon orientation, were first set based on the local meteorological measurements (i.e., at Princeton) in the baseline scenario and then modified to explore their individual impacts on RR cooling performance.

Results and Discussion

Enhanced cooling with synergistic reflective benefits

The cooling effects of RR material on urban canyon surface and air temperatures were assessed for diverse RR material types and on urban façades and grounds. We

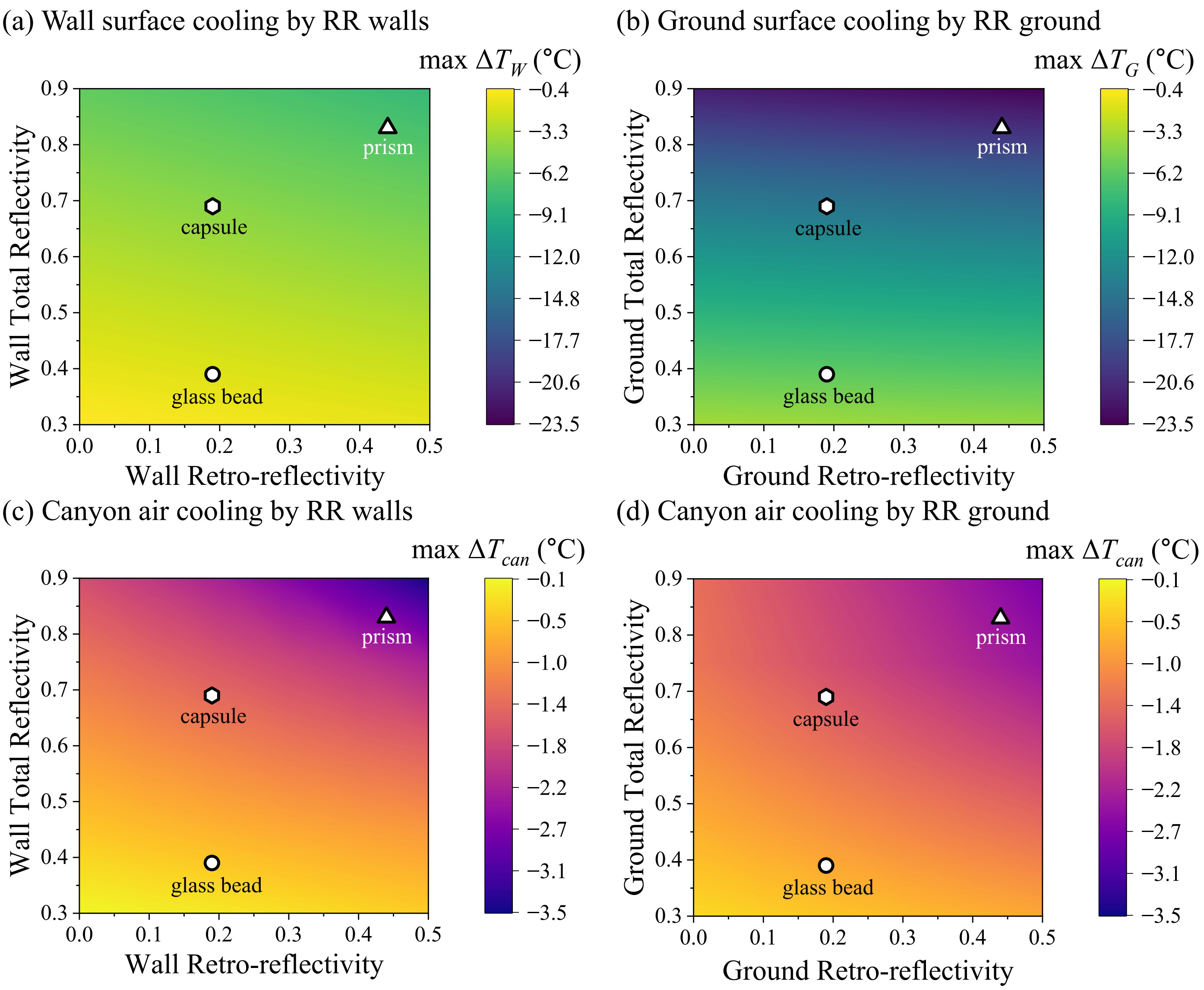

Figure 2. (a) Wall surface cooling (max ΔT_W) by RR walls, (b) ground surface cooling (max ΔT_G) by RR ground, and canyon air cooling (max ΔT_{can}) by (c) RR walls and (d) RR ground with different total reflectivity and retro-reflectivity.

first tested various combinations of total reflectivity and retro-reflectivity in their common ranges (0.3 – 0.9 and 0 – 0.5, respectively) set based on three typical RR types. We tested normal walls+ground (baseline scenario), RR walls (i.e., RR walls+normal ground, Fig. 2a and 2c), and RR grounds (i.e., RR grounds+normal walls, Fig. 2b and 2d), separately. The cooling effects (ΔT_W, ΔT_G, ΔT_{can} for wall, ground, and canyon air temperatures, respectively) were evaluated by comparing the RR wall or ground scenarios against the normal baseline scenarios.

Fig. 2a and 2b present the maximum surface temperature reductions for RR walls ($\Delta T_W = \Delta T_{W}$,RR – $\Delta T_{W,normal}$) and RR ground ($\Delta T_G = \Delta T_{G,RR} - \Delta T_{G,normal}$), respectively. We found that RR walls can lead to a substantial wall surface cooling benefit of −0.4 to −8°C, and RR ground results in an even more significant surface cooling that is largely attributed to the high albedo (with a minimal impact of retro-reflectivity). Fig. 2c and 2d present the maximum canyon air temperature reductions ($\Delta T_{can} = \Delta T_{can,RR} - \Delta T_{can,normal}$) by RR walls and RR ground, respectively. In the test range, RR walls and ground both show an evident cooling effect by reducing urban canyon air temperatures by 0.1 – 3.5°C (Fig. 2c) and 0.3 – 2.7°C (Fig. 2d), respectively. On these figures, we also denoted three common types of RR material based on their reference optical properties: prism (α=0.83, η=0.44), capsule (α=0.69, η=0.19), and glass bead (α=0.39, η=0.19). Note that these reference values are based on test results of previous studies, while specific values in practice may vary with different manufacturing technologies and material aging. The prism RR material yielded the best performance, resulting in a maximum reduction of −2.6°C (applied on walls) and −2.5°C (applied on the ground) in canyon air temperature. These reductions were −2.1°C and −1.7°C higher than the least effective type (glass bead) for wall and ground applications, respectively. Hereafter, we will mainly use the op-

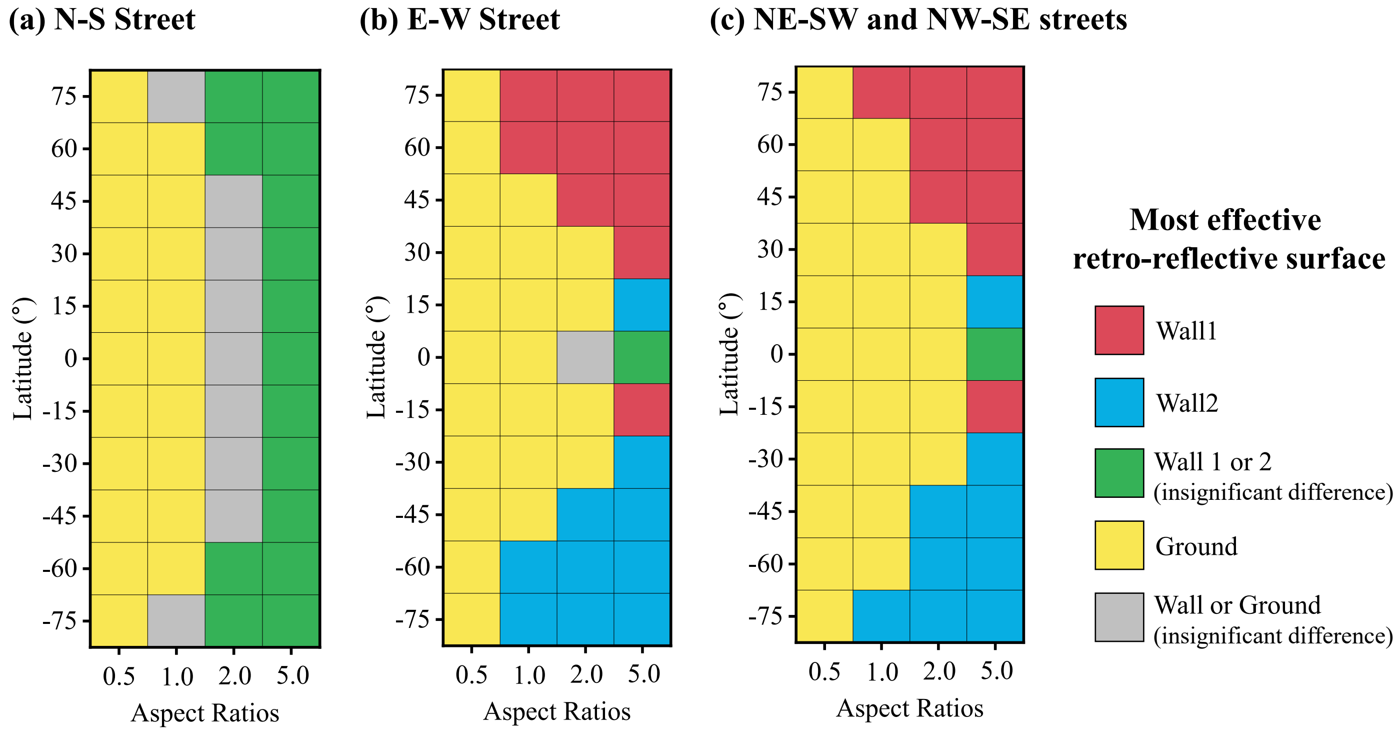

Figure 3 Most effective retro-reflective surface to mitigate summertime extreme heat for different latitudes and aspect ratios in a (left) N-S street, (center) E-W street, and (right) NE-SW or NW-SE street.

timal type (i.e., prism) to show the maximum potential cooling benefits of RR materials.

Direct assessment of human thermal comfort benefits is more informative for evaluating RR surfaces as a cooling strategy than relying solely on surface/air temperature reductions. PUCM-RR can capture changes in human thermal stress responses (represented as human skin temperature, T_{skin}) and energy exchanges (e.g., net human radiation: the sum of net (incoming – outgoing) shortwave and longwave radiation, $R_{nh} = SW_{in} - SW_{out} + LW_{in} - LW_{out}$) induced by different urban environmental variation. With PUCM-RR, we tested HR and RR walls and grounds, as well as their combination (walls+grounds), to compute the changes in human skin temperature (Tskin) and human radiation budget ($\Delta R_{nh} = \Delta R_{nh,RR} - \Delta R_{nh,HR}$). We found RR surfaces improve pedestrian thermal comfort by reducing human skin temperatures by up to –0.55°C compared with HR surfaces, especially during the hottest hours (10:00-16:00). By observing the diurnal profiles of human net radiation changes, it is clear that shortwave radiation reduction (up to –138W/m^2) plays a dominant role in offsetting the higher reflection from the higher total albedo of RR material on pedestrians, and longwave radiation reduction (up to –15W/m^2) induced by urban surface temperature reduction shows persistent but minor impacts over the diurnal cycle.

Global generalized design guidelines

To better enable real-world deployment across worldwide cities, it would be more pragmatic to apply RR material to a specific urban surface rather than attempting to cover all facets of an entire city. Therefore, optimal selection of the most effective RR surface is of significant practical importance. Combining global spatiotemporal solar radiation distribution and various local street geometries, we aim to propose worldwide generalized design guidelines for more effective and efficient RR surface implementation. In this section, we tested normal and RR materials for different latitudes (from 75° N to 75° S with intervals of 15°), months (each 21st day for January to December), street orientations (N-S, NE-SW, E-W, and NW-SE), and aspect ratios (0.5, 1, 2, and 5).

For the optimization, we used the "maximum canyon shortwave radiation reduction" (i.e., max ΔS_{can}) in summer (representative days: the 21st days of June, July, and August for the Northern Hemisphere; the 21st days of December, January, and February for the Southern Hemisphere) to identify the most effective RR surface. This optimization criterion directly measures the amount of untrapped radiation by RR surfaces, and can be further transferred to many specific heat-related applications (e.g., energy, temperature, comfort) by local researchers and practitioners. The single most effective RR surface with greater than 10% difference relative to other surfaces was highlighted in Fig. 3 with different colors, while multiple most effective RR surfaces were also denoted if insignificant differences (i.e., lower than 10%) were found among them.

As depicted in Fig. 3, identification of the most effective RR surfaces is highly dependent on street orientation. N-S streets (Fig. 3a) present the simplest case: the most effective RR surface shifts predominantly according to urban geometries. Ground and walls are clearly favored for low and high aspect ratios, respectively, with negligible differences between the two walls. For E-W and diagonal streets (Fig. 3b-c), the Sun path in the sky leads to more complicated results with shifting of the most effective RR surfaces at different latitudes. At low aspect ratios (e.g., 0.5), the ground is dominantly preferred at all latitudes; with aspect ratios increasing (e.g., at 1 and 2), wall1 (south-facing) and wall2 (north-facing) become more advantageous at high latitudes for the Northern and Southern Hemispheres, respectively. At the highest aspect ratio of 5, high and low latitudes exhibit different optimization results, e.g., in the Northern Hemisphere, south-facing (wall1) and north-facing (wall2) are preferred for high and low latitudes, respectively, due to different Sun paths. These results for the low latitudes are due to the fact that significant insolation of the wall only occurs during the early morning and late afternoon when the Sun angle in the sky is low, and the Sun path is such that the insolated walls at those times are the north-facing and south-facing ones in the Northern and Southern Hemispheres, respectively.

Conclusion

We proposed the application of mature RR technologies over urban skins to tackle the urban overheating challenge. The mechanism behind this is to undo one of the main drivers of urban heat island effects: the geometric trapping of radiation in the complex and dense urban canopies. Our results quantified the great potential of RR surfaces to provide enhanced cooling benefits and counteract some deficits of traditional HR materials, and emphasized the importance of appropriate RR type selection for urban cooling. We revealed that implementing the most effective RR material (prism) on walls and grounds decreases urban canyon air temperatures by up to 2.6°C and 2.5°C, respectively, and contributes to multi-faceted cooling benefits for the other surface (up to −3.3°C) and pedestrians (up to −0.55°C in skin temperature and −153 W/m2 in net radiation compared with HR surfaces). To facilitate effective and efficient implementation of RR surfaces, we developed optimal design guidelines for cities worldwide considering diverse street geometries (e.g., aspect ratios and street orientations) and climatic conditions (e.g., latitudinal and seasonal solar radiation variation). Synthesizing the above research findings, we provided an optimization matrix to illustrate the most effective RR surface for alleviating summertime extreme heat for global cities across latitudes and urban densities.

Acknowledgements

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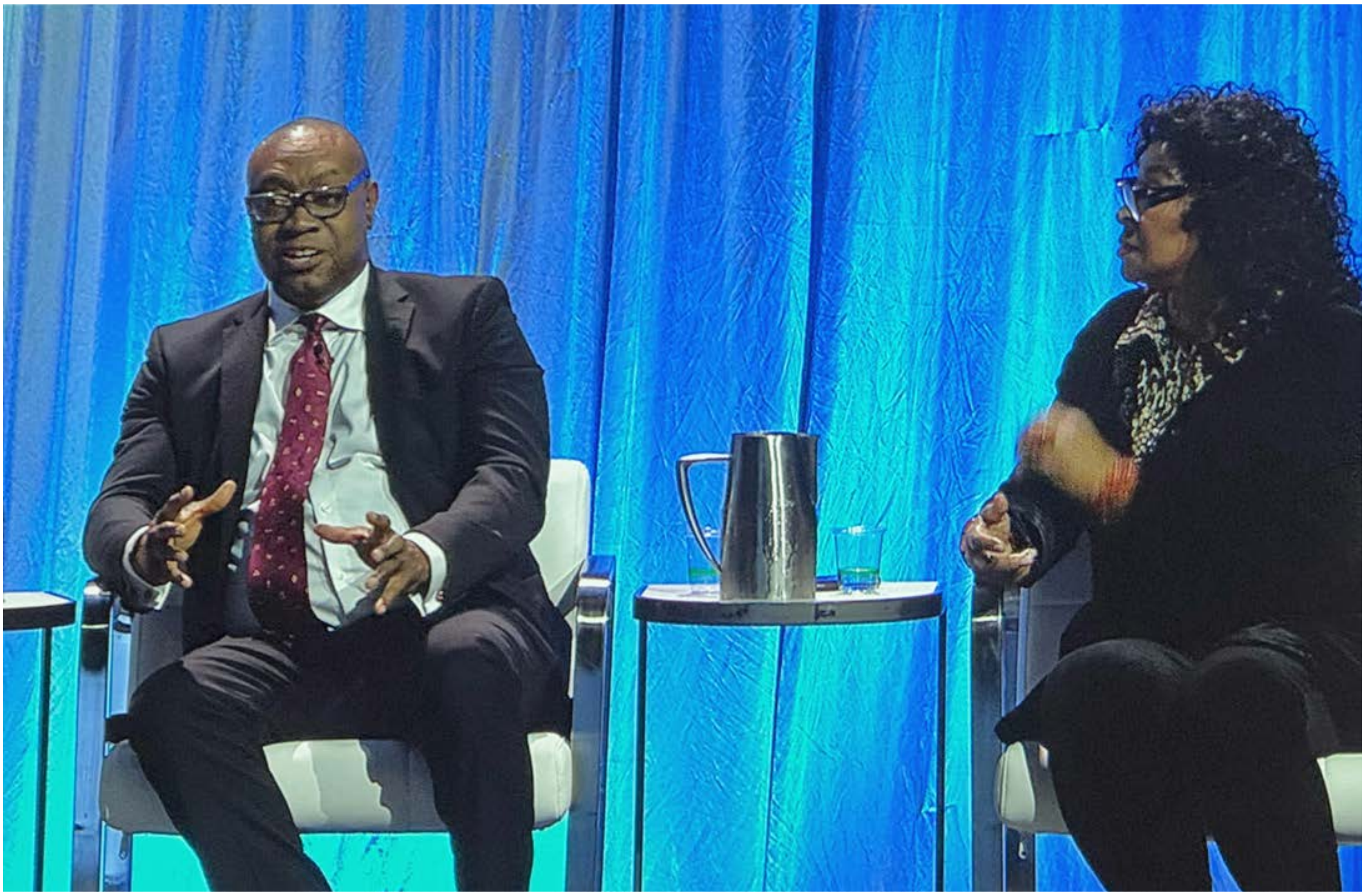
Thousands of researchers, professionals and students gathered on January 12–16 in New Orleans to share the latest meteorological science and address key issues in weather, water, and climate

This year marks the 20th anniversary of Hurricane Katrina, an event whose devastating impacts on the people of New Orleans are still felt today. Katrina's presence was palpable at the 105th Annual Meeting of the AMS, where the vulnerability of the host city to natural hazards and climate-induced environmental change is surpassed only by its cultural vibrancy and resilience.

This theme of urban risk and resilience was highlighted in the keynote event of the conference, a panel discussion entirtled "Physical, Social, Cultural, and Economic Impacts: The Gulf Coast as a Microcosm of Global Change." Dr. **Virginia Burkett**, Chief Scientist for Climate and Land Use Change at the USGS, introduced the context by showing how the city's location on the Mississippi River delta is "one of the most rapidly changing and vulnerable coastal landscapes on planet earth – uniquely and inimately linked with weather, climate and changes in mean sea level." The president of UCAR, Dr. **Antonio J. Busalacchi**, continued by presenting NOLA and the gulf ecosystem as a prime example of how the earth is a coupled system, which joins the physical, natural and human environment. He quoted then-President Biden's words after the terrorist attack in the French Quarter just two weeks before the conference: "New Orleans defines strength and resilience, be it hurricane Katrina, the deep horizon explosion, or the disproportionate effects from Covid."

Dr. **J. Marshall Shepherd**, distinguished Professor of Geography and Atmospheric Sciences at the University of Georgia and former president of the AMS, recounted his testimony before congress on the extent to which extreme weather events are becoming increasingly complex and compounded – and how Gulf Regions are partucularly at risk. Drawing from a recent report on Compounding Disasters in Gulf Coast Communities, he summrized his "5 R's": The *Risk* to communities from compounding disasters requires a new kind of *Response* – not only to single disasters, but to the co-occurrence of multiple and varied disruptive events; it also requires *Resilience* in order to absorb the effects of these hazards, *Remembering* past experience to avoid complacency, and *Recovery* as an "epochal" community process that plays out over a prolonged period.



Dr. J. Marshall Shepherd and Dr. Beverly L. Wright discussing climatic risk as an issue of environmental justice for communities along the gulf coast, where extreme events are becoming increasingly complex and compounded.

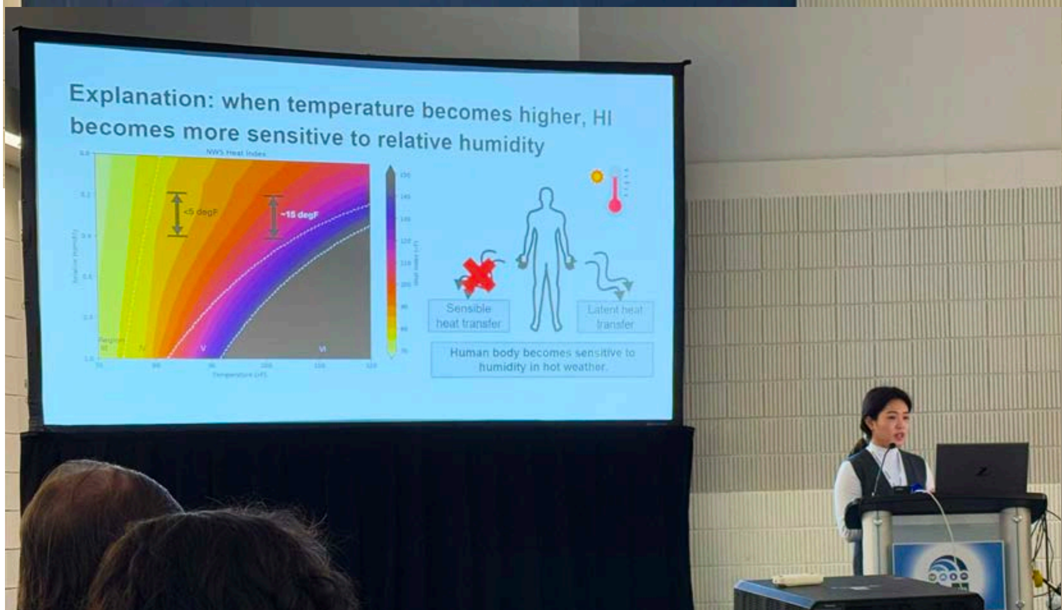
The panel culminated with a message from Dr. **Beverly L. Wright**, Professor of Sociology and director of the Deep South Center for Environmental Justice. A civic leader and eighth-generation native of New Orleans, Dr. Wright conveyed how Hurricane Katrina was the event that made people wake up to the reality of environmental injustice. "Low-income and minority communities suffer from both higher socio-economic stress and greater exposure to toxins, hazardous wastes and other environmental burdens," she said, emphasizing that Katrina contributed to pushing local communities out of New Orleans – threatening the very culture that makes it so alluring to visitors. In the face of this reality, she proposed, what is needed is a "just" transition to a socially and environmentally sustainable economy.

Spotlight on Urban Climate

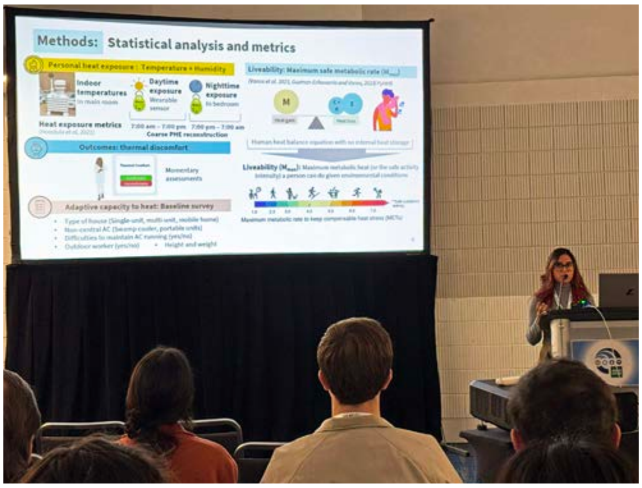
Within the sprawling AMS conference, a three-part series of sessions focused on "Urban Scale Climate Impacts and Mitigation: Developing an Observational and Modeling Integration". The sessions were chaired by **Rao Kotamarthi** (Environmental Science Division, ANL) and **Matei Georgescu**, (SGSUP, Arizona State University), and were part of the *29th Conference of Applied Climatology* (see detailed program and recordings at https://ams.confex.com/ams/105ANNUAL/meetingapp.cgi/Program/1805)

Additional issues that are critical for urban climatology were addressed within the *16th Conference on Environment and Health* (full details at https://ams.confex.com/ams/105ANNUAL/meetingapp.cgi/Program/1836). These included a session on "Novel Assessment of Heat Exposure and Risk," chaired by **Lena Easton-Calabria** (RAND Corporation) and co-chaired by Jaime Madrigano (Johns Hopkins University) and Shubhayu Saha, (Centers for Disease Control and Prevention), two sessions entitled "Merging Environmental and Health Data for Climate Resilience in the Face of Extreme Weather" chaired by **Gabriel Michael Filippelli** (Indiana University) and co-chaired by Kris Karnauskas (University of Colorado), Jane Baldwin (University of California) and Azar Abadi (University of Alabama), and one session on "Environmental Health Across Urban Scales" chaired by **Peter Crank** (University of Waterloo) and co-chaired by Elizabeth Doran (University of Vermont), Chandana Mitra (Auburn University) and Prathap Ramamurthy (CUNY City College).

— *David Pearlmutter, Editor*



Scientific research and policy studies addressing urban heat and health risks were ubiquitous at AMS in New Orleans. Half of the city's neighborhoods have less than 10% tree canopy cover, and increasing heat stress is becoming a critical concern - just as it is in countless urban areas across the globe.



Within the overall AMS annual meeting, the 29th Conference of Applied Climatology included a three-part series of sessions focused on "Urban Scale Climate Impacts and Mitigation: Developing an Observational and Modeling Integration". Additional issues that are critical for urban climatology were addressed within the 16th Conference on Environment and Health, including a session on "Novel Assessment of Heat Exposure and Risk," two sessions entitled "Merging Environmental and Health Data for Climate Resilience in the Face of Extreme Weather", and one session on "Environmental Health Across Urban Scales." In addition to the oral presentations, a rich offering of poster presentations addressed these urban issues as well.

Recent Urban Climate Publications

In this edition, we present a list of publications in the field of urban climate mainly published between **November 2024** and **February 2025**. Featured papers, denoted by an asterisk symbol (*), are recommended by members of the Bibliography Committee. If you believe your articles are missing from this compilation, please send the references to my email address below with the subject line "IAUC publications" and the following format: Author, Title, Journal, Year, Volume, Issue, Pages, Dates, Keywords, DOI, and Abstract.

For this quarter, Namrata Dhamankar-Jadhav concluded her term after 2 years of dedicated service. Thank you, Namrata, for your enthusiasm and contribution to the community!

We are always seeking researchers at all career stages, particularly early-career professionals, to join our committee and actively contribute to the IAUC community. If you are interested in joining or would like to acquire further details, please do not hesitate to contact me via email.

Happy reading,

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Abdel-Gadir SEM, Mohammed MGA (2024) Oman's Green Horizon: Steering Towards Sustainability Through Decarbonization and Energy Transition. *Sustainability* **16** 9375.

Abdelsamie EA, Mustafa A-rA, El-Sorogy AS, Maswada HF, Almadani SA, Shokr MS, El-Desoky AI, de Larriva JEM (2024) Current and Potential Land Use/Land Cover (LULC) Scenarios in Dry Lands Using a CA-Markov Simulation Model and the Classification and Regression Tree (CART) Method: A Cloud-Based Google Earth Engine (GEE) Approach. *Sustainability* **16** 11130.

Abdi AP, Damci A, Kirca O, Turkoglu H, Arditi D, Demirkesen S, Korkmaz M, Arslan AE (2024) A Spatial Decision-Support System for Wind Farm Site Selection in Djibouti. *Sustainability* **16** 9635.

Abduljaleel Y, Chikabvumbwa SR, Haq FU (2025) Assessing the efficacy of Permeable Interlocking Concrete Pavers (PICP) in managing stormwater runoff under climate change and land use scenarios. *Journal of Hydrology* **646** 132329.

Abid I, Hechmi S, Chaabouni I (2024) Impact of Energy Intensity and CO2 Emissions on Economic Growth in Gulf Cooperation Council Countries. *Sustainability* **16** 10266.

Adamovic D, Adamovic S, Cepic Z, Moraca S, Mihailovic A, Mijailovic I, Stosic M (2024) Possibilities of Improving the Emission Characteristics of Passenger Cars by Controlling the Concentration Levels of Combustion-Generated BTEX Components. *Sustainability* **16** 11033.

Adamtsevich L, Pustovgar A, Adamtsevich A (2024) Assessing the Prospects and Risks of Delivering Sustainable Urban Development Through 3D Concrete Printing Implementation. *Sustainability* **16** 9305.

*Ahmad J, Sajjad M, Eisma J (2025) Small unmanned aerial vehicle (uav)-based detection of seasonal micro-urban heat islands for diverse land uses. *International Journal of Remote Sensing* **46** 119–147.

Ahmed N, Luqman M (2024) Explaining urban communities' adaptation strategies for climate change risk: novel evidence from Rawalpindi, Pakistan. *Natural Hazards* **120** 6685–6703.

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Alavez-Ramirez R, Chinas-Castillo F, Martinez-Reyes J, Caballero-Montes JL, Caballero-Caballero M, Morales-Dominguez VJ, Ortiz-Guzman M, Robledo-Taboada LH, Juarez-Arellano EA, de la Rosa LE (2024) Thermal Performance of Novel Eco-Friendly Prefabricated Walls for Thermal Comfort in Temperate Climates. *Sustainability* **16** 9349.

Alcibahy M, Gafoor FA, Mustafa F, El Fadel M, Al Hashemi H, Al Hammadi A, Al S. MR (2025) Improved estimation of carbon dioxide and methane using machine learning with satellite observations over the Arabian Peninsula. *Scientific Reports* **15** 766.

Aleksejeva J, Voulgaris G, Gasparatos A (2024) Systematic review of the climatic and non-climatic benefits of green roofs in urban areas. *Urban Climate* **58** 102133.

Alghamdi AH, Alonaizi FA, Almalki MA (2024) Investigating the Structural Framework Beneath Riyadh Region for Potential Geothermal Exploration Utilizing Geological and Geophysical Data. *Sustainability* **16** 11286.

Al-Habaibeh A, Watkins M, Shakmak B, Javareshk MB, Allison S (2024) Assessing air quality and physical risks to E-scooter riders in urban environments through artificial intelligence and a mixed methods approach. *Applied Energy* **376** 124282.

Al-Homoud M (2024) Enhancing Supportive and Adaptive Environments for Aging Populations in Jordan: Examining Location Dynamics. *Sustainability* **16** 10978.

Alisoltani T, Motlagh MS, Ashrafi K (2024) Concurrent heat stress and air pollution episodes by considering future projection of climate change. *Scientific Reports* **14** 29301.

*Allen-Dumas MR, Sweet-Breu LT, Brelsford CM, Wang L, New JR, Bass BC (2024) Sensitivity of mesoscale modeling to urban morphological feature inputs and implications for characterizing urban sustainability. *Npj Urban Sustainability* **4** 49.

Almansour M, Akrami M (2024) Towards Zero Waste: An In-Depth Analysis of National Policies, Strategies, and Case Studies in Waste Minimisation. *Sustainability* **16** 10105.

Almheiri A, Montenegro JF, Ewane EB, Mohan M (2024) Climate change hazards and the resilience of coastal cities in the Gulf Cooperation Council countries: A systematic review. *City and Environment Interactions* **24** 100177.

Al Mobin M (2024) Forecasting dengue in Bangladesh using meteorological variables with a novel feature selection approach. *Scientific Reports* **14** 32073.

Aloshan M, Gharieb M, Heba KM, Khalil R, Alhumaid MH, Ezz MS (2024) Promoting Urban Corridors in Saudi City Center to Enhance Walkability Using Multi-Criteria Decision-Analysis Methods. *Sustainability* **16** 9255.

Al-Sager SM, Almady SS, Al-Janobi AA, Bukhari AM, Abdel-Sattar M, Al-Hamed SA, Aboukarima AM (2024) Modelling of Carbon Monoxide and Suspended Particulate Matter Concentrations in a Rural Area Using Artificial Neural Networks. *Sustainability* **16** 9909.

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Upcoming Conferences...

12TH INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC12)
Rotterdam, The Netherlands • July 7-11 2025
http://icuc12.eu

Registration for ICUC12 in Rotterdam is now open at:
https://www.icuc12.eu/attend/register.html
The early bird deadline is May 29th at 13:00 CEST.

ASIA OCEANIA GEOSCIENCES SOCIETY (AOGS)
Singapore • July 27-August 1, 2025
https://www.asiaoceania.org/aogs2025/
Sessions on "Urbanization-induced LULC Changes and its association with Climatology, Extreme Weather and Risks", "Urban Weather and Climate", and "Direct Flux Measurements for Immediate Societal Benefits"

AMERICAN GEOPHYISCAL UNION (AGU)
New Orleans, USA • December 15-19, 2025
https://www.agu.org/fall-meeting/
AGU's Annual Meeting convenes attendees from 100+ countries to share scientific findings and make connections. Researchers, scientists, educators, students, policymakers, exhibitors, journalists and communicators attend the meeting to better understand our planet and environment, and our role in preserving its future.

Only 2 months to go! **ICUC-12** will start off on July 7th 2025 in Rotterdam (the Netherlands). With great pleasure we announce that more than 1000 abstracts have been submitted to the conference, which means you as urban climate community will make ICUC12 a great event all together!

The registration for ICUC-12 in Rotterdam is now open at https://www.icuc12.eu/attend/register.html. The early bird deadline is May 29th at 13.00 CEST. The complete conference program will become live at www.icuc12.eu mid-May, but we can already announce some highlights:

Three keynote speakers:

Elie Bou-Zeid, Director Program in Environmental Engineering and Water Resources, Princeton.

Carola Hein, professor in "Water, Ports and Historic Cities"".

Edward Ng, CUHK School of Architecture, Luke Howard Award winner 2024.

Tuesday afternoon: Excursion time!

The excursion programme has been released! We offer 6 excursions to:

The Green Village at TU Delft
Climate Adaptive walk
Rooftop hop: Multiroofs
Rotterdam Architecture Tour
From Harbour to City
Manhattan on the Maas

More detail at https://www.icuc12.eu/attend/excursions.html. You find the registration form for the excursions in the registration workflow for the conference as a whole.

Wednesday

Plenary round-table discussion panel on IPCC Special Report on Cities Conference Dinner in Maassilo.

Thursday is Practitioners Day!

We are excited to announce "Practitioners Day" during ICUC-12, taking place Thursday, July 10th. This event aims to bridge the gap between research and practice, showcasing innovative solutions for urban climate challenges and fostering collaboration among practitioners, researchers, and policymakers. The day will feature a series of engaging workshops and sessions (all in English) designed to stimulate discussion, share knowledge, and highlight the latest advancements in urban climate strategies. We especially invite people from practice to join us and discuss their work! We feature a selection of workshops and sessions (from the regular week programme) targeted towards practice.

GitHub workshop by the NLeScienceCenter

In this free hands-on workshop by Peter Kalverla and Claire Donnelly, we introduce the basics of version control and collaborating on code with GitHub. We explore how this can help us produce more reproducible and sustainable scientific projects. This workshop is for early career researchers who code on their own and want to learn how to share and collaborate. Basic command-line skills required. Limited to 20 participants, first come first served. Sign up here: https://tinyurl.com/icuc-git-signup!

Workshops

During the week a chain of workshops will be organized (details at https://meetingorganizer.copernicus.org/ICUC12/sessionprogramme)

- Urban Climate Walks
- Knowledge Exchange on Urban Greening: increasing impact through stakeholder engagement and interdisciplinary perspectives
- Implementation of urban climate knowledge in urban design processes
- Guidelines for Urban Climatic Maps
- Heat-resistant Buildings
- Wind in the City
- City4CFD
- GeoClimate
- Using UMEP in Urban Climate Research - a practical workshop for beginners and advanced users

Early Career Scientist Events

- ECS1 Research Speed Dating: Junior meet seniors to learn how to develop a successful career!
- ECS2 How to get published in Scholarly Journals: writing, reviewing and ethical issues.

We look forward to meet you in Rotterdam!

On behalf of the local organizing committee,

Marjolein van Esch and Gert-Jan Steeneveld
Conference Co-Chairs

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The next edition of *Urban Climate News* will appear in late September. Contributions for the upcoming issue are welcome, and should be submitted by September 1, 2025 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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