

OPINION

Integration of urban climate research within the global climate change discourse

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Global climate science needs to address a fundamental challenge: the mismatch between the scales of anthropogenic processes driving change and the resulting climate impacts. While projected climate changes and impacts are global in extent, the drivers of this change, and the exposure to its impacts, are concentrated in densely populated urban areas. Despite occupying only 1–3% of the land, urban areas are home to most of the world's population and responsible for ~70% of current greenhouse gas emissions [1]. By 2050, an additional 2.5 billion people are expected to live in urban areas, with up to 90% of this growth anticipated in the Global South with increased rates of vulnerability. The importance of cities in our climate change dialogue will therefore not diminish but rather become increasingly more significant.

Despite the vital role of cities, urban-scale climates are poorly represented in global climate science (both in observations and models). Urban climate research has also been traditionally underrepresented in the assessments of the physical basis of climate, with the inclusion of cities not being formalized until the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which emphasized adaptation and mitigation. This has several consequences. First, a rich body of existing knowledge on urban climates is ignored, particularly in IPCC science assessments. Second, there has been little incentive to measure and understand climate processes at urban scales, which further undermines the accuracy of current climate assessments. Third, urban policies to mitigate and adapt to climate change may not account for unique climate consequences in cities. This limits our ability to develop effective strategies for climate adaptation and mitigation, posing additional risks to the future resilience of societies.

There is a unique opportunity to remedy this situation with the planned Special Report on Climate Change and Cities as part of the IPCC's 7th Assessment Cycle. This marks the first time the IPCC has dedicated a coordinated effort focused on cities. This initiative is timely, addressing stakeholder demand for policy-relevant information in urban areas and considering two developments in urban climate science research. First, there is evidence that cities not only create distinctive climates but also impact regional climates and extreme events beyond

their physical boundaries. The contribution of urbanization to urban temperature, for example, can equal or exceed the global climate change signal in many cities [2]. Urbanization similarly exacerbates heatwaves, alters the water cycle, and generates increased precipitation over and downwind of some cities. These regional effects, on par with those of non-urban land cover change, underscore the role of cities in exacerbating climate hazards in compounding ways that are not yet systematically quantified [3].

Second, advances in climate modeling at various scales have achieved higher resolutions, making omitting urban areas increasingly problematic. While models at a ~50 km resolution or coarser might justify focusing on broader-scale processes, finer resolution simulations suffer from significant biases if urban areas are neglected. This is especially the case for kilometer-scale simulations that many major modeling centers are now attempting.

Over the last 35 years, an active interdisciplinary Urban Climate Research community has acquired substantial knowledge and understanding of urban modifications to micro- to meso-scale climates. At their most recent tri-annual gathering, the 11th International Conference on Urban Climate (ICUC11) held at the University of New South Wales in 2023, 640 experts gathered to discuss the latest developments in urban climate science. This community plays a pivotal role in integrating the physical understanding of urban climate processes in global climate change discussions.

One of the most prominent discussions at ICUC11 centered around strategies to enhance our community's active involvement in shaping present and future global initiatives, including, but not limited to, IPCC reports. Our commentary reflects on these discussions, declaring and underscoring the collective commitment of the urban climate community to achieving a broader impact in climate change discourse (Fig 1).



Fig 1. The urban climate community at the 11th International Conference on Urban Climate, UNSW Sydney (Australia), August 2023.

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It is paramount that the Urban Climate community engages in strategic and coordinated planning to meet this historic opportunity provided by the IPCC Special Report on Climate Change and Cities and the 7th Assessment Report (AR7). To do so, three pivotal aspects should be addressed and strengthened:

- **Prioritize urban-scale technological advancements:** There is a pressing need to improve the capabilities of high-resolution global and regional climate models and better understand global climate interactions with city-scale processes. Capturing these interactions requires a range of observations across scales, from novel remote sensing platforms to fine-scale IoT sensor platforms, in addition to improved modelling capabilities. It is particularly important to better capture urban dynamics across spatial and temporal scales in larger (regional to global) climate models and further develop a hierarchy of approaches (at different spatial and temporal scales) to quantify the two-way interactions between cities and climate change.
- **Facilitate cross-disciplinary and cross-scale synergies:** The evolving focus on the impact of climate change on urban communities necessitates integrating urban climate research into broader-scale climate assessments. The impact of climate change on cities, as well as the impact of cities on climate change, can no longer be assessed in isolation. There is a strong need for synergistic approaches that go beyond disciplinary focuses and put urban climate research into the context of not only climate impact assessments but also applications (such as climate services) and policies that can be taken up by city governance.
- **Increase urban climate visibility and presence:** Streamlining the process for integrating urban climate research into IPCC assessments requires a stronger presence of urban climate experts across all three IPCC working groups in various capacities, including as scoping experts, authors, and expert reviewers. Furthermore, integration of our work requires not only better communication of aggregated knowledge in urban climate research (synthesized from various case studies in different cities and climatic contexts) but also better integration in the global sustainability context.

To inform various steps of this process, the urban climate community has a responsibility to **identify and address the most critical research gaps that are relevant to the nexus of cities and climate change**. This covers research areas including, but not limited to: urban climate modeling across scales (including urban representation in the next generation of high-resolution global and regional climate models as well as climate projections at the city scale), urban climate observations (including remote sensing, in situ, and urban climate informatics), urban climate hazards and their compounding impacts (such as heat, air quality, flood), urban greenhouse gas emissions, urban climate justice, as well as integrated urban climate services developed across global case studies.

Equally important is synthesizing and aggregating existing urban climate knowledge in various subfields in ways that are robust, comprehensive, and accessible to IPCC authors with expertise in various climate disciplines. This synthesis could focus on developing urban typologies that codify settlements based on urban form, structure, metabolism, and networks, and their implications on climate adaptation and mitigation. For these syntheses to be effective, they should be achieved with urban stakeholders from diverse topical, career stages, and geographic representations that contribute to aggregating and synthesizing state-of-the-art knowledge.

Our community pledges to champion robust knowledge synthesis, inclusive representation, and active engagement, aiming to shape the global discourse on climate change and urban environments for a sustainable future.

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