Ran Wang · Meng Cai
Chao Ren · Yuan Shi *Editors*

# Local Climate Zone Application in Sustainable Urban Development

## Experience from East and Southeast Asian High-Density Cities

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Cover image: LCZ map of South China developed in the study of "Detecting multi-temporal land cover change and land surface temperature in Pearl River Delta by adopting local climate zone"

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# Foreword

The late Jason Ching's seminal paper (Ching et al. 2009) titled "National Urban Database and Access Portal Tool (NuDAPT)" published in 2009 established the theoretical framework of using high-resolution urban morphological features in meteorological, air quality, and other modeling systems for urban application. This was followed by Iain Steward's Local Climate Zones (LCZ) for urban temperature studies, which established a comprehensive, and yet simple to reference, classification system of urban features (Steward and Oke 2012). Subsequently, in 2018, Jason followed up with WuDAPT – The World Urban Database and Access Portal Tools (Ching et al. 2018). WuDapt basically combines the theoretical framework of NuDAPT and LCZ. Since then, scholars all over the world have made use of WuDAPT for their urban climate related studies.

The book by Wang et al. is timely for the very reason that the world's cities are rapidly urbanized and densified. The world has more than 35 megacities, and the number is increasing (UN 2018). These cities house millions of inhabitants. The book starts with a general introduction of LCZ and its technicalities. It then moves on to how the learning may be applied to the study of urban heat island, the wind environment, energy consumption, carbon emission, thermal comfort, and so on. To me, the most important chapter is 13 as it tries to relate the scientific understanding to planning strategies. In short, "doing is more important than knowing."

As I am writing this foreword, the world has just experienced the hottest July ever. UN Secretary-General António Guterres calls it, "The era of global boiling has arrived." Scientists have warned that there is now a 66% chance that we will pass the 1.5 °C global warming threshold between now and 2027 (WMO 2023). At least 10 countries and territories saw severe flooding in just 12 days in September 2023 (CFR 2023). All the signals have warned us that: the need to do something shifty, proactively, and diligently for our cities is now more urgent than ever. Let's get on with it.

Hong Kong, China
7 October 2023

Edward Ng

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# Foreword

The pace of urbanization changed so rapidly in the twentieth century that the world population living in cities now exceeds those in rural areas, and by the end of the twenty-first century, it is estimated that 80% of the world's population will be urban. In the interim, cities are modified and new ones arise to accommodate urbanization. The form and function of these built environments will modify their local climates; given rapid changes to climate, globally, there is a great need to understand, predict, and assess the impact and risks at the local scale on the quality and ability to sustain life in cities. The beginnings of this millennium saw advanced schemes that link numerical descriptions of the urban landscape (urban canopy parameters, UCPs) to atmospheric responses and first introduced into Mesoscale Meteorological Models (MMMs). These urbanized models have provided opportunities to conduct research on weather-related topics that are impacted by cities (including the urban heat island phenomena, urban precipitation effects, and air quality). However, a major barrier to the application of these urbanized models has been a general lack of UCP information on cities impeding progress on urban climate science and the development of multi-scale weather/climate modeling. The World Urban Database and Access Portal Tool (WUDAPT) project was created to overcome this data gap by generating climate-relevant urban data that are publicly available. WUDAPT was launched at the 8th International Conference on Urban Climate (ICUC8) in Dublin (Ireland) in 2012 (Ching et al. 2018) to acquire information on aspects of form and functions of cities relevant to climate studies, make accessible such data in a geographic framework that is searchable and widely accessible with portal tools to extract parameters, and analyze urban properties for cross-urban comparison and model building. WUDAPT takes its inspiration from the NUDAPT project (Ching et al. 2009), which generated gridded UCP data for several cities in the USA using detailed municipal data on building footprints and heights, and road networks, for example. However, to generate useful UCP data at a global scale, a different approach is needed as urban geospatial data is either not available or does not exist. WUDAPT employed the Local Climate Zone (LCZ), a climate-relevant universal framework, to describe land usage in urban areas. This scheme categorizes urban landscapes into one of ten types alongside an additional seven natural types (Stewart and Oke

2012). Each LCZ type is associated with a range of values for a set of fundamental urban canopy parameters (e.g., impervious surface cover, building data and street-level view factors, etc.), which are applicable at a local scale (<1 $km^2$). In the WUDAPT project, the LCZ classification for cities was derived using remote sensing techniques and GIS mapping methods (see Bechtel et al. 2015) that subsequently evolved to generate continental scale and global LCZ maps (Demuzere et al. 2022). These geospatial databases of LCZ types are also maps of UCP values that can be incorporated into a suite of models (e.g., SUEWS and WRF). The development of the LCZ mapping tool and the creation of large-scale LCZ (and UCP) maps is a major achievement of the first decade of WUDAPT. Like NUDAPT, each member parameter of the set for each grid in urban domains has a unique value; this is property of urban canopies that is the bases for intra-urban scale modeling in mesoscale models such as WRF.

WUDAPT had its beginnings in Hong Kong. Gerald Mills, Iain Stewart, Chao Ren, myself, and other contributors to WUDAPT and to this book participated in the Croucher ASI (Advanced Study Institute) on "Urban Climatology for Tropical and Subtropical Regions" held at the Chinese University of Hong Kong on 5–10 December 2011. At this ASI, fresh from his PhD defense of his Local Climate Zone scheme, Iain inspired us to the potential merits of this climate relevant universal approach for describing land cover and usage in urban areas anywhere in the world. Gerald Mills and I presented a proof-of-concept demonstration using LCZs in WRF for Dublin at the IAUC's 8th ICUC Symposium in Dublin. The IAUC subsequently initiated the WUDAPT project as a strategic gap filling approach to urban climate science. The subsequent decade has yielded a capability to generate city specific to global mapping of LCZ achieved through this international urban community collaborative activities. Challenges due to expected exacerbations of climate change and urbanization issues in this Anthropocene, WUDAPT is proposing a path forward strategic TESTBEDS collaborative approaches. The concept of TESTBEDS is to identify and test various "Fit for Purpose" science-based study prototype applications and approaches using LCZ-based advanced urban data, generating capabilities to problems of predicting intra-urban impacts of weather extremes, air quality and exposure studies, and human comfort at intra-urban scales by collaborating teams of interested urban climate science specialists.

This book is written by many inspired by their first exposure to the LCZ concept at Croucher ASI2011. It is an important segue to these highly significant WUDAPT milestones and path forward approaches that address challenges of the Anthropocene, marked by climate change induced largely by the release of various greenhouse gases from aggressive urbanization and now impacting the growing numbers of urban dwellers. It begins with a global view of urbanization, climate science, basic concepts, methodology, and techniques of LCZ data developments. It follows with various applications presenting systematically the latest LCZ applications by taking Asian high-density cities as examples of LCZ demonstrated in practice including application to urban heat island, land use and land cover analysis, wind environment, energy consumption, thermal comfort studies, and so on. It draws heavily upon the Asian experience where urbanization is so pronounced evident by the rapid

numbers of new megacities emerging in this region. It is an important testimony to the global impact of LCZ and will serve the global community with example templates applicable everywhere else. Lastly, this book concludes the progress, challenges, limitations, and future work of LCZ-related studies.

These past fifty years, I have been fortunate to have had the opportunity to be engaged in environmental research and methods development with a primary focus on urban science issues. I am so honored to provide the Foreword to this important book and have personally benefitted from collaborations with most of its authors.

Chapel Hill, USA Jason Ching
14 August 2023

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# Preface

There have been over ten years since the putting forward of the Local Climate Zone (LCZ) classification scheme by Stewart and Oke. Numerous studies employing LCZ have been published worldwide in the fields of classification algorithms, urban climatic modeling, urban heat islands, wind environment, air pollution, outdoor thermal comfort, land use and land cover, urban morphology detection, energy consumption, carbon emission, etc., and there is still an increasing trajectory of research publications on LCZ. The applicability, suitability, and effectiveness of the LCZ scheme to urban climate and environment research have been confirmed by the rising popularity of its application among researchers. Hence, here we came out the idea for preparing this book. We noted that it is time to summarize the progress of LCZ-based studies, review the state-of-the-art of developed technology and methodology, and discuss potential solutions for how to integrate LCZ into planning practice.

When preparing this book, we cannot imagine that the era of "Global Warming" has ended although we all have experienced more frequent and intensified heatwaves over the last decades. Particularly, these extreme high-temperature events occurred in regions with non-tropical/subtropical climates, like North China. Not surprisingly, academia, government, commercial, and other sectors show less confidence in the 1.5 °C temperature increase set by the Paris Agreement. In July 2023, the United Nations Secretary-General said, "The era of global boiling has arrived." With sustained climate change in the future, a deteriorated living environment for city dwellers can be foreseen. Under such circumstances, urban climate science and its application in planning practice become urgent. LCZ, thanks to its characteristic of "morphology language" understood by planners and architects, is one suitable bridge to link scientific understandings and planning/design practice. We invited a number of experts with rich experiences of LCZ applications from a range of diverse disciplines, all of whom recognize the importance of scientific evidence-based planning and attempt to contribute to building a sustainable and comfortable living environment from various aspects, including wind, temperature, energy consumption, public health, and so on.

This book aims to illustrate the development of urban datasets with detailed urban morphology and metabolic information and their applications in different urban climatic and environmental fields. The book consists of 13 chapters arranged over four sections. The first section introduces the general background of rapid urbanization and urban climatic issues in high-density cities. The second section shows the technical details of LCZ classification with both fundamental and advanced methods. The third section presents a wide range of LCZ applications in Asian high-density cities to indicate how the LCZ scheme can improve urban climatic studies at a fine scale in a complicated urban context. The final section proposes possible ways of combining climate knowledge into urban planning. We sincerely hope that this book could serve as a useful reference for environmental scientists, climatologists, geographers, and researchers in other relevant fields, as well as professionals in planning and design, urban management, and policy-making. No doubt, this book is also suitable for undergraduates and postgraduates with a general interest in urban climate science and climate-sensitive planning.

Tianjin, China — Ran Wang
Wuhan, China — Meng Cai
Liverpool, UK — Yuan Shi
Hong Kong, China — Chao Ren
October 2023

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We would like to thank the Springer editor team and supporting staff who gave us such an opportunity to realize our idea and subsequently provided strong editing support throughout all the stages of the publication process.

Chapters in this book were contributed by researchers in various research fields from different Asian countries. We are very grateful for their huge effort in writing and revising these chapters and for bearing with us when we push them during the whole preparation process. Especially over the last three years of the COVID-19 pandemic, they still worked with us to prepare this book.

We also acknowledge the endeavor of Dr. Justin Ho who has done excellent work in formatting and editing all the manuscripts. His careful and patient work guarantees the quality of this book.

Additionally, we, as the book editors, are thankful to the international community of urban climate, environment, public health, social and economic researchers, city planners, architects, government officials and policymakers for their persistent efforts in combating climate change and improving our living environments, especially as we are facing a more uncertain future under climate change.

Last but not least, we would like to dedicate this book to Dr. Jason Ching, a pioneer and leader in promoting both NUDAPT and WUDAPT, as well as the application of LCZ. We were so shocked that Dr. Ching suddenly passed away in early September 2023. His work and influence have encouraged many young researchers, including ourselves, to immerse themselves in LCZ-related studies. Most importantly, his spirit inspires us to pursue science as a lifelong learning journey, to step out of our comfort zones by collaborating with others and to ensure that our research has a real impact on people and society.

# Contents

# Contributors

**Guangzhao Chen** is a research assistant professor in the Division of Landscape Architecture at the University of Hong Kong. He received his BS and PhD degrees in Geographical Information System from Sun Yat-sen University. His research concerns the interaction and relationship among climate change, urban development, and human activities. Specifically, his main research areas include land use classification, land use change modelling, and urban climate mapping and assessment. His research on future land spatial projections has significantly improved the spatial resolution and involved land types of future land datasets under climate scenarios, greatly enhancing the mainstream land data used in current global climate research. His proposed future land datasets and corresponding environmental assessments under climate scenarios have been directly adopted by the IPCC's Sixth Assessment Report, promoting the development of global climate change research. His efforts in high spatio-temporal resolution mapping and assessment of the urban thermal environment have also made innovative explorations in urban climate research.

**Lamuel Chi Hay Chung** is a PhD candidate in the School of the Environment at the University of Queensland, specializing in spatial ecology. His research, titled "Persistence of Spotted-Tail Quoll under Future Climate and Land-Use Changes," explores the impacts of climate and land-use changes on this vulnerable species using spatially explicit metapopulation model. Lamuel's academic journey began with a BA in Anthropology from the Chinese University of Hong Kong in 2016. He then pursued an MEnvM in Conservation Biology at the University of Queensland in 2019, where his fascination with spatial ecology and remote sensing blossomed. Before commencing his PhD, Lamuel gained valuable experience as a research assistant at the State Key Laboratory of Marine Pollution at the City University of Hong Kong from 2021 to 2022 and worked with Ren Chao's Urban Climate Lab at the University of Hong Kong from 2019 to 2021. His diverse research interests have led to publications spanning multiple disciplines, including ecology, remote sensing, urban studies, and machine learning. Lamuel is also an accomplished drone pilot and internationally awarded nature photographer.

**Jimmy Chi Hung Fung** is a chair professor at the Division of Environment and Sustainability at Hong Kong University of Science and Technology (HKUST). With a specialization in atmospheric sciences, air quality modeling, and remote sensing technology, he has conducted extensive research on air pollution in Hong Kong and the Pearl River Delta Region. His current research focuses on comprehending, predicting, and assessing meteorological and air pollution problems in urban and coastal environments. Prof. Fung's mesoscale modeling system has been widely utilized in educational and research programs, including the study of regional climate change, wind fields associated with the large-scale monsoon circulation, pre-summer severe rainstorms, typhoons, the regional thermally forced land-sea breeze circulation, and the impact of regional urban built form. His expertise in applying advanced atmospheric and chemistry models, such as CMAQ, has enabled him to study air quality over HK and PRD regions down to street scales.

**Aveek Ghosh** is a senior research fellow, who holds a postgraduate degree in the field of sustainable architecture with a demonstrated history of working in the research industry. Presently, he is conducting his doctoral studies on "Vulnerability assessment of heat waves in the heat-prone Indian cities" at the Department of Architecture and planning, Visvesvaraya National Institute of Technology (VNIT), Nagpur, India. His fellowship investigates the distribution of heat stress across different local climate zones while adopting a novel approach to calculate heat hazard risk at a local level. He has multiple research publications in the field of urban heat stress, planning interventions for extreme heat, and urban policies to address the complex issues of urban climatology. He has presented award-winning research papers at prestigious international and national conferences with a passion for interdisciplinary and collaborative research. His work is at the intersection of urban planning, climatology, and geography, which demonstrates a holistic approach to understanding and mitigating the impacts of rising temperatures in urban environments. His current research interest focuses on extreme heat planning and governance, risk perception among individuals, developing heat-related urban policies, and effectively managing extreme heat in urban settings.

**Rajashree Kotharkar** (architect and urban planner) is a professor at the Department of Architecture and Planning, Visvesvaraya National Institute of Technology (VNIT) Nagpur, India. She works in the realm of climate responsive architecture, urban environmental research exploring the impact of urban morphology on heat stress distribution, outdoor thermal comfort, heat risk perception, heat vulnerability, and sustainable urban development. She has completed multiple national and international projects and publications distilled from a scientific understanding of multifarious dimensions of urban heat. Her current work focuses on heat wave studies, developing and implementing intervention policies for urban heat risk mitigation and adaptation. She is an expert committee member for review of National Disaster Management Authority guidelines on heat wave preparedness. She is also an Energy Conservation Building Code trainer and part of the expert committee in State Disaster Management Authority of Maharashtra and National

programme on climate change and human health. She investigates intra-urban thermal contrast through the application of local climate zone (LCZ) framework. Her research provides valuable insights on sustainable urban development, energy policy, heat response planning, and risk adaptation strategies in rapidly urbanizing cities, ultimately aiming to improve the quality of life in urban areas while addressing climatic concerns.

**Kevin Lau** is an urban climatologist who has been working in climate-sensitive urban planning and design for 15 years. His primary research interest is on the relationship between the built environment and urban climate, with a particular focus on human thermal comfort in outdoor environment. He is also experienced in exploring the inter-relationships between the built environment, climate, and health and well-being. He has extensive experience in inter-disciplinary research, which transfers scientific knowledge into practical guidance in climate-sensitive urban planning and design. He was the principal investigator of many projects commissioned by government departments, non-governmental organizations, and private sectors.

**Sheng Liu** is currently an assistant professor in the School of Architecture, Southwest Jiaotong University. He received his PhD in Architecture from the Chinese University of Hong Kong in 2021. He was a postdoctoral fellow in the Department of Architecture, the University of Hong Kong. He had worked as an architect in mainland China before starting academic research. His research interests focus on climate-responding architecture design and low-carbon city design. Dr. Liu has published more than 20 leading peer-reviewed scientific journal publications for the past five years, such as *Building and Environment*, *Sustainable Cities and Society*, *Energy and Buildings*, including two ESI highly citied papers. He is also the recipient of Postgraduate Research Output Award of the Chinese University of Hong Kong in 2022.

**Zeting Li** a PhD student at University College Dublin who works on urban climate under the supervision of Assoc. Prof. Gerald Mills and funded by the Next-Generation Energy Systems (NexSys) program. He received his bachelor's degree in Surveying and Mapping at the China University of Geosciences, Beijing, and completed an MSc in Geospatial Data Analysis at University College Dublin. His research interests are in climates, particularly the interrelationship between climate change and cities. He employs geospatial big data in his research to evaluate climate-related urban risks and examine climate change adaptation and mitigation strategies in cities.

**Zhenning Li** is a research assistant professor at the Division of Environment and Sustainability (ENVR), HKUST. He has 4 years of working experience as a climate scientist and dedicates himself to exploring the climate change physics and their risks posed to communities, economy, and other dimensions of society. With expertise in multi-scale climate modeling, he has conducted extensive regional dynamical downscaling simulations to provide scientific-based qualitative and quantitative evidence to measure future climate risks in Hong Kong and the Greater Bay Area. He

is also building a regional air-wave-ocean coupled model to investigate extreme weather events and their responses in future climate. For his doctoral research, he used to focus on circulation responses to tropical atmospheric convections by conducting comprehensive general circulation model experiments. Zhenning Li is also keen on the open-source community and developed a set of popular research toolkits on GitHub.

**Xingcheng Lu** currently holds the position of assistant professor in the Department of Geography and Resource Management at the Chinese University of Hong Kong (CUHK). Prior to his appointment at CUHK, he served as a research assistant professor at the Hong Kong University of Science and Technology. Dr. Lu's primary research focus encompasses the development and application of 3D chemical transport models, exploration of atmospheric chemistry, estimation of air pollutants through machine learning techniques, and analyses of air pollutant source apportionment and associated health impacts. Presently, Dr. Lu is engaged in research exploring the effects of urbanization on meteorological fields and air pollution, utilizing the Local Climate Zone dataset.

**Gerald Mills** is a geographer and climatologist at UCD, Dublin. His interest in urban climatology includes the measurement and modelling of urban climate effects and developing the means to acquire climate-relevant data on cities worldwide (the WUDAPT) project. He has been involved in the International Association for Urban Climates (IAUC) from its inception in 2000, was President from 2009 to 2013, and organized the International Conference on Urban Climates in Dublin (ICUC8) in 2012. He is coauthor of Urban Climates, a comprehensive survey of the state of knowledge in urban climate science, and he received the Luke Howard Award for lifetime contribution to urban climatology from the IAUC in 2021.

**Iain D. Stewart** holds a PhD in geography from the University of British Columbia (UBC) in Vancouver, Canada. He is currently a sessional lecturer in urban meteorology at UBC and a fellow of the Global Cities Institute in Toronto. Iain is a recipient of the prestigious "Timothy Oke Award for Original Research in Urban Climatology," and a two-time recipient of the "William P. Lowry Methodology Prize," given by the International Association for Urban Climate. Iain serves as an associate editor for the journal *Urban Climate* and is coauthor of the text *The Urban Heat Island: A Guidebook*.

**Aanchal Vidyasagar** is a landscape architect from School of Planning and Architecture, New Delhi (India). A custodian of nature, research oriented, an analytical academician and is on a constant quest to explore, learn, and unlearn. After practicing and teaching in the domain of landscape architecture for over seven years, she is currently pursuing her doctoral studies at Visvesvaraya National Institute of Technology (VNIT-Nagpur). Her research is focused on understanding the potential of urban green infrastructure to mitigate urban heat island effect and thus, prepare a heat mitigation plan for heterogeneous Indian cities. She has a keen

interest in multi-disciplinary research which interacts within and beyond the realms of landscape architecture, urban planning, climatology, governance and development management.

**Michael Mau Fung Wong** is a postdoctoral fellow at the Division of Environment and Sustainability (ENVR), HKUST. He is an urban meteorologist specializing in mesoscale urban modeling. His work encompasses diagnostic downscaling, terrain flow studies, and integrating urban data into mesoscale models to enhance their application in urban environments. Currently, he is leveraging machine learning techniques to improve urban meteorology simulations, focusing on more accurate urban weather forecasting. His expertise also includes remote sensing, particularly in analyzing urban heat islands and retrieving urban building datasets. He is currently working on the improvement and sensitivity of the urban model in WRF. He is also involved in projects that couple Planetary Boundary Layer (PBL) schemes with urban models, aiming to identify and implement model improvements.

**Cheolhee Yoo** obtained his PhD in the Department of Urban and Environmental Engineering from Ulsan National Institute of Science and Technology (UNIST), South Korea, in 2022, and his BE in the Department of Urban and Environmental Engineering from UNIST in 2017. Dr. Yoo served as a postdoctoral fellow at the Hong Kong Polytechnic University (PolyU) from April to September 2022. Currently, he holds the position of Research Assistant Professor at PolyU. He is an editorial board member of the *ISPRS Journal of Photogrammetry and Remote Sensing* and *GIScience and Remote Sensing*. His research interests include remote sensing, urban sustainability, and the use of artificial intelligence to interpret remote-sensing images for disaster management and environmental monitoring.

**Le Yu** is an associate professor at the Department of Earth System Science, Tsinghua University. His research has been on the use of geographical information techniques to monitor and model global land use change, especially cropland, and to facilitate many applications, e.g., food security, biodiversity conservation, and land system modelling. He particularly focuses on satellite-based methods to quantify the spatiotemporal change of land cover/use and understand their ecological, environmental, and socioeconomic impacts on sustainable development. He is Scientific Steering Committee (SSC) member of the Global Land Programme (GLP), Fellow of the Royal Geographical Society (RGS-IBG), Fellow of the Higher Education Academy, Senior Member of the Institute of Electrical and Electronics Engineers, and Prominent Visiting Researcher at the University of Technology Malaysia (UTM). He is currently editor-in-chief of *Geo: Geography and Environment*, section editor-in-chief of LAND, associate editor of *International Journal of Remote Sensing*, and editorial board member of *Global Sustainability and Geoscientific Model Development*.

**Jiyao Zhao** is advancing toward the completion of his PhD at Tsinghua University's Department of Earth System Science. His research navigates the effects of urbanization on climate systems. He employs a blend of field surveys, multi-source data

analysis, and computer modeling to address urban challenges within the broader context of global environmental change. His work involves (1) globally tracking and detailing changes in land use and cover; (2) more accurately representing the evolution of urban environments; and (3) evaluating the environmental impacts of urban growth, differentiating the outcomes of urban sprawl from redevelopment. Jiyao is dedicated to merging rigorous research with practical urban planning, working with multidisciplinary teams to develop sustainable and realistic urban strategies.

**Yingsheng Zheng** is an associate professor at the School of Architecture and Urban Planning and serves as the deputy director of the Department of Architecture at Guangzhou University, China. Over the past decade, Dr. Zheng has collaborated closely with scholars from fields of sustainable planning, urban climate studies, geography, and computer science, to engage in interdisciplinary research related to low-carbon urban planning, urban climate risk assessment, and climate-adaptive design. She has won the Professor Kao Kun Innovation Award of the Chinese University of Hong Kong, the Jin Jingchang China Urban Planning Outstanding Paper Award, and the Urban Climate Journal Top Cited Paper. During her tenure as a registered architect and sustainable design consultant at Leigh and Orange Ltd in Hong Kong, Dr. Zheng played an active role in promoting sustainable design and construction projects within the Guangdong-Hong Kong-Macao Greater Bay Area. Representative planning projects include the Lok Ma Chau Loop Hong Kong-Shenzhen Innovation and Technology Park and the Hong Kong Science and Technology Park, InnoCell Talent Apartment, Shenzhen Qianhai Times TOD, etc.

**Xilin Zhou** is an assistant professor in the School of Civil Engineering and Architecture, Wuhan University of Technology; special researcher in Tokyo Institute of Technology; member of the Architectural Society of China and the Architectural Society of Japan; the outstanding young talent of "Wuhan Talents." He got the PhD in Architecture and Building Science from Tohoku University, MS in Architecture from Wuhan University of Technology, BE in Civil Engineering, and BA in English from Wuhan University of Science and Technology. With a multidisciplinary educational background, he has published more than 30 articles in a variety of research areas including the wind, thermal, sound, health, and economic issues related with the built environment. He is the PI of one national foundation and one provincial foundation, respectively.

**Ziping Zuo** is a PhD student specializing in climate change and future climate projections at the Division of Environment and Sustainability (ENVR), HKUST, under the guidance of Prof. Jimmy C. H. Fung. Her research initially focused on future and present hot extreme events in the Pearl River Delta (PRD) region. Her current investigations expand to encompass other future extreme weather phenomena, such as extreme precipitation and cold extremes. Passionate about unraveling the intricacies of the changing climate, she employs diverse methodologies to comprehend its impacts. Through interdisciplinary collaboration, she strives to contribute valuable insights toward a more sustainable and resilient future.

# About the Editors

**Ran Wang** is an assistant professor in the College of Economic and Social Development at Nankai University, China. Her research interests mainly include urban climate and sustainable urban design or planning with a focus on the urban thermal environment, land use and land cover change, and urban heat mitigation. She has much experience in modeling and analyzing urban morphology and thermal environments using geospatial analysis, urban climate models and remote sensing techniques. Her research has been published in several journals with high reputations in urban climate and urban planning. She also leads multiple national and international projects on how cities mitigate and adapt to climate change at various scales.

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