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# The 9th International Conference on Urban Climate

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ABSTRACT

The study of urban climates now represents a full scientific field on its own. The 9th International Conference on Urban Climate (ICUC-9), held in July 2015 in Toulouse, France, provided a recent forum for urban climate scientists to share the results of their research. This introduction paper presents the 20 articles of this special issue. They are representative of the variety of the themes that are encompassed by the urban climate community: study of urban climate processes, new observational and modeling techniques and methods, urban design with climate, geospatial datasets, bioclimatology and health, interdisciplinarity, climate change mitigation & impacts in urban environments, and transfer of urban climate knowledge to urban planners. These papers were selected from student awards winners as well as from more senior researcher contributions. ICUC-9 was the largest ICUC held to date, reflecting the increased interest in climate and meteorology at the urban scale by the research community. The selection of articles helps point towards areas of future urban climate research. More planners, social scientists and scientists from outside the 'pure' discipline of urban climate were present than during previous editions, allowing the rise of new themes as interdisciplinary and transfer to urban planners.



## 1. The conference

The study of urban climates now represents a full scientific field on its own. The growth in urbanization worldwide has induced many societal and scientific questions related to the impact of cities and human settlements on the atmosphere, at various temporal and spatial scales. From its early beginnings in the 1960s, when the first observations of urban meteorological processes appeared and the study of urban climates

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expanded from descriptive climatologies, the field of urban climatology has expanded to include closer links with meteorology and has matured to become a predictive scientific field of study.

The 9th International Conference on Urban Climate (ICUC-9), held in July 2015 in Pierre Baudis congress center, Toulouse, France, provided a recent forum for urban climate scientists to share the results of their research. The ICUC conference series is organized on behalf of the International Association for Urban Climate (IAUC) on a triennial basis. ICUC-9 is the continuation of a series of similar conferences starting in Kyoto, Japan in 1989, followed by those in Dhaka, Bangladesh in 1993, Essen, Germany in 1996, Sydney, Australia in 1999, Lodz, Poland in 2003, Göteborg, Sweden in 2006, Yokohama, Japan in 2009, and Dublin, Ireland in 2012. ICUC-10 is scheduled for New York, USA in 2018. The success of this series has helped to create a cohesive international community of urban climate scientists. The aims of these conferences are to provide an international forum where the world's urban climatologists can meet to showcase and discuss modern developments in research, and the application of climatic knowledge to the design and management of cities. They cater to the interests of a diverse community of meteorologists, climatologists, hydrologists, ecologists, engineers, architects, urban planners and others interested in these topics.

ICUC-9 was held jointly with the 12th Symposium on the Urban Environment organized by the Board of the Urban Environment of the American Meteorological Society. For five full days from July 20–24, 2015, nearly 600 delegates from more than 60 countries representing every continent, shared their results, exchanged views, opened new collaborations and discussed future research (Fig. 1). ICUC is also the formal moment during which the urban climate community, through the IAUC, rewards eminent researchers for their carrier and contribution to urban climate with the Luke Howard award (Fig. 2). During ICUC-9, Professors Kanda and Brazel received the 2014 and 2015 Luke Howard awards, respectively.

Perhaps due to the crucial societal issues arising in Asian megacities, scientists from Asian countries (mostly from Japan, China, Hong-Kong, Korea) formed the largest group of attendees, followed closely by scientists from European countries. While most urban climate research has often focused on mid-latitude cities, ICUC-9 included many presentations of work on tropical cities in Africa, South-America and Asia. In total, 338 oral thematic presentations (Table 1) were organized in four parallel sessions, and nearly 300 posters were presented. All the abstracts and the majority of oral presentations are available online on http://www.meteo.fr/icuc9.

The conference sessions were organized following eight themes (Table 1). Four plenary sessions by renowned researchers were representative of the variety of conference themes: Robert Bornstein from San José State University, USA, focused on the physical processes of how cities impact precipitation and thunderstorms. Lee Chapman (University of Birmingham) presented new possibilities for intra-urban meteorological networks composed of hundreds of stations, with the arrival of connected and low cost stations, and the forthcoming revolution of crowd-sourced data. These sensors and networks may help overcome limitations of past urban climate observations that have often been limited to either a few site measurements, or a more spatially intensive, but temporally limited network operated during experimental campaigns, In the framework of climate (and global) changes, Andrew Coutts from Monash University, Melbourne, Australia, focused on advances of urban greening adaptation strategies and urban tree benefits. Edward Ng, from the Chinese University of Hong Kong presented his architect's view on how to transfer the relevant climate information to urban planners in an efficient manner and how to tackle the coming climate change challenges in Asian cities.

The 20 articles of this special issue are representative of the variety of the themes that are encompassed by the urban climate community. They were selected from student awards winners as well as from more senior researcher contributions.

## 2. Classical disciplinary themes

As expected, classical disciplinary themes studied by the urban climate community for several decades, were well represented:

- Sessions on the ‘Study of urban climate processes’ form the disciplinary core of urban climate understanding. Many results on urban climate processes in the atmospheric boundary layer were found by coupling several instrumental techniques or instruments, with remote sensing information more widely used. High performance computing facilities, sometimes associated with new models, allowed flow dispersion studies with large eddy simulations or process studies related to the impacts of urban vegetation at various scales (from tree to canopy). Studying the impact of Tokyo, Japan on precipitation using a non-hydrostatic


**Fig. 1.** Participants of the ICUC-9.

**Fig. 2.** a) Co-chairs of ICUC-9 (V. Masson, left and A. Lemonsu, right) with T. Oke, first Luke Howard award recipient; b) J. Voogt, IAUC president, giving 2014 Luke Howard award to Pr M. Kanda.

atmospheric model at kilometric resolution, Seino et al. (2018–this issue) found a thermally induced change in circulation, particularly enhanced ascending motion, and subsequent precipitation for afternoon rainfall cases without preceding precipitation. Kokkonen et al. (2018–this issue) study the sensitivity of modeling of the surface energy and water balances against long-term measurements in Vancouver, Canada and London, UK. Finally, Oliphant et al. (2018–this issue) conducted an original flux tower experiment during the Burning Man event in the desert of Nevada, USA, that measured energy and $CO_2$ fluxes associated with this ephemeral, one week, 70,000 inhabitants 'city'. Surprisingly, surface radiation and energy fluxes were remarkably unchanged after the development of the city. The energy balance resembled other arid surfaces and somewhat other urban surfaces, though with little anthropogenic and much less heat storage flux than traditional cities, while $CO_2$ sources were mostly stationary, related especially to on-site electricity generation for air conditioning units.

- 'New observational and modeling techniques and methods to study urban climate' gathered high quality innovation on those long-studied techniques. Richter et al. (2018–this issue) developed a gust generator within wind tunnel laboratory experiments in order to investigate the interactions of downward convective gusts the urban canyons, and show that the induced wind velocities can be higher than in open terrain. Voogt and Dyce (2018) developed a sensor view model that includes trees using a gap probability approach to estimate foliage view factors and an energy budget model for leaf surface temperatures. The model is used to better understand and potentially correct urban thermal anisotropy. Gao et al. (2018–this issue) show the potential of unsteady RANS approach for neighbourhood scale studies. Interest in studies of $CO_2$ fluxes, which gained prominence in previous ICUCs, was continued at ICUC-9. Bjorkegren and Grimmond (2018–this issue) compare $CO_2$ fluxes in an urban environment using an inventory method of all sources and from a micro-meteorological flux tower. The two methods yield similar estimates. Their results support the use of vertical fluxes calculated from eddy covariance measurements at a single location to estimate total emissions from high density urban environments.
- 'Urban design with climate' sessions were dedicated to architectural and planning techniques and practices in order to take advantage of, or adapt to, current climate, either following theoretical approaches or for several regions in the world. Representing this theme, Qüense et al. (2018–this issue) compare urban canyons designs in Conception, Chile, crossing morphological information, micro-meteorological measurements and surveys. Skelhorn et al. (2018–this issue) investigate the relationship between Urban Heat Island and impacts of vegetation during a summer month (July) and a winter month (December) and explore the implications for building energy demand and associated carbon emissions in Manchester UK.
- While sessions on 'geospatial datasets' were also held at previous ICUCs, ICUC-9 marked the first time a common vision of land use description, the Local Climate Zones concept, had been clearly widely adopted by the urban climate community. This is a promising development for future studies on the climate of cities, not only from the geospatial point of view, but also in order to provide a common interpretation frame for urban heat island (and other) studies or for urban climate model inputs. The special issue features two papers in this theme. Perera and Emmanuel (2018–this issue) study the LCZ maps of Colombo, Sri Lanka with several levels of classification nomenclature.

**Table 1**
ICUC9 themes overview (see also IAUC newsletter, 2015).

| ICUC9 oral presentations by themes and topics (number of presentations) | |
|---|---|
| **Climate change mitigation & adaptation in urban environments (41)** | |
| Cities inside climate models and downscaling methods (6) | UHI mitigation strategies: |
| Climate modeling: methodologies for impact studies (6) | Urban expansion and climate change links (3) |
| | Urban planning (6) |
| Climate Impact studies and adaptation strategies (4) | Watering process studies (6) |
| | Vegetation management processes (2) |
| Urban air pollution mitigation strategies (3) | Vegetation based strategies (5) |
| **Transfer of urban climate knowledge to urban planners (37)** | |
| Public policies and practices (5) | Indicators and climate maps: |
| Governance challenges in urban planning & adaptation (5) | Risks and vulnerability (4) |
| Development/amendment of urban planning regulation (5) | Urban planning (3) |
| Weather forecasting for city actors (5) | Warning plans and decision support tools (10) |
| **Study of urban climate processes (77)** | |
| UHI characteristics: | Impact of cities on precipitation (7) |
| Link with boundary layer (5) | Influence of urban vegetation: |
| Vertical and horizontal structure (6) | Urban trees (9) |
| UHI micro-scale variability (6) | Parks and green roofs (6) |
| Observations of surface energy and water balances (3) | Flows and dispersion: |
| Air quality in the urban boundary layer: processes (9) | Pollutant dispersion in urban canopy (3) |
| Observations of greenhouse gases fluxes (6) | Effects of atmospheric stability (6) |
| Radiation processes (3) | Turbulent and dispersive fluxes in urban canopy (5) |
| Influence of mesoscale flows (3) | |
| **Geospatial datasets (37)** | |
| Surface UHI from satellite (4) | New remote sensing technology and data (2) |
| Local climate zones: | Urban databases and link with models (7) |
| WUDAPT (6) | Urban climatology studies: |
| Methodologies and maps (3) | Temperate and cold climate cities (3) |
| Inter and infra-LCZ temperature variability (6) | Tropical and arid climate cities (6) |
| **New observational and modeling techniques and methods to study urban climates (67)** | |
| Urban canopy parameterizations: | Urban climate measurement networks (8) |
| Urban vegetation (7) | Field campaigns (6) |
| Development and sensitivity (5) | Mesoscale and numerical weather prediction models (10) |
| Statistical models (4) | New sensors/new methods: |
| Computational Fluid Dynamics models (4) | $CO_2$ and mobile measurements (7) |
| Large Eddy Simulation models (6) | UBL and UHI (4) |
| Wind tunnel and scale models (6) | |
| **Bioclimatology and public health (25)** | |
| Modeling of outdoor microclimate and comfort (6) | Health (6) |
| Indoor comfort and link with outdoor conditions (3) | Human perception and new indicators (6) |
| Observation/surveys of outdoor comfort (4) | |
| **Urban design with climate (43)** | |
| Impact of urban form on comfort: | Building climate and energy consumption: |
| Tropical and arid climate cities (6) | New models (4) |
| Temperate and cold climate cities (7) | Temperate and cold climate cities (7) |
| Theoretical studies (3) | Tropical, continental and arid climate cities (5) |
| Impact of urban form on outdoor ventilation (5) | Energy demand at city scale (6) |
| **Interdisciplinarity (11)** | |
| Environmental scholarship and collaborations (2) | Multicriteria environmental perception (9) |

## 3. Interdisciplinary themes

Because of the intrinsic complexity of cities, four other themes, of a more interdisciplinary nature, were addressed during the conference. These sessions were also well subscribed by participants (see Table 1):

- 'Bioclimatology and health' addressed issues related to human comfort in cities arising from meteorological conditions and urban climate. Lam et al. (2018–this issue) explored human thermal perception during heatwaves in Melbourne parks. They observed that local visitors felt significantly hotter than inhabitants and suggest that thermal expectation influences changes in thermal perceptions and clothing, even over the course of several days to a week. da Silveira et al. (2018–this issue) present the results of investigations on pedestrian comfort carried out in Belo Horizonte Brazil, a tropical climate, and in Kassel and Freiburg, Germany, a temperate climate.
- 'Interdisciplinary' sessions encompassed sociological studies with a broader vision of the urban environment, where urban climate is only a part of the processes considered. These are a relatively new addition to our scientific community and reflect the importance of the integrated socio-physical environment in urban environment studies. Lenzholzer et al. (2018–this issue) present a review of novel qualitative methods that deliver an explicit combination of thermal and spatial information. They allow to document the fact that thermo-spatial perception is influenced by a range of dimensions: the nature and scale of spatial contexts, the kinetic state of the people and the time scale of their perception ('now' or 'the past'). Emmanuel (2018–this issue) reformulates thermal pleasure in the tropics, a concept that needs to be coupled with non-thermal attributes of the urban commons, and focuses on specifying standards for 'cool' urban spaces that enhance greater tolerance of warm conditions indoors.
- 'Climate change mitigation & impacts in urban environments' was a clearly growing topic at ICUC-9 compared to previous ICUCs (it was almost non-existent a decade ago). Most presentations in this theme were dedicated to the urban scale, hence focused on adaptation issues. This can be linked to community history, that is more focused on the city scale than on larger and global scales. Urban greening, from impacts to management issues, were extensively discussed during the conference, and are shown to be an efficient way to mitigate the Urban Heat Island, at least in mid-latitude or dry-climate cities. de Munck et al. (2018–this issue) and Daniel et al. (2018–this issue) present adaptation strategies of Paris, France to heat waves based on urban vegetation and watering practices, respectively. Vegetation watering is found to be efficient in reducing air temperature and thermal stress, but mostly in residential areas where vegetation density is important enough, while the pavement watering is relevant in the densely built city centre. Broadbent et al. (2018–this issue) investigates the potential of purposefully managed irrigation for cooling benefits in a suburb of Adelaide, South Australia, where 'integrated urban water management', which provides a unique opportunity for passive evaporative cooling of urban environments, is widely adopted.
- Finally, the theme 'Transfer of urban climate knowledge to urban planners' was new to ICUC-9. This theme was only sparsely represented, and not identified as a session topic, in previous ICUCs. Its promotion to a conference theme, comes from the desire of the organizers for the urban climate science community to not only produce science, but also to produce science that is *usable by and transferable to* society. Identified end-users include urban planners and city actors. Baklanov et al. (2018–this issue) underlines that the World Meteorological Organization (WMO) on the recent World Meteorological Congress emphasized that the rapid urbanization that is currently taking place will require new types of services making best use of science and technology and considered this problem as one of its main priorities. Baklanov et al. (2018–this issue) hence presents a broad view of all the associated challenges towards Integrated Urban Weather, Environment and Climate Services. Klok and Kluck (2018–this issue) propose a mind map to visualize the large number and variety of heat-related risks that can also be a helpful visual for urban professionals in outlining the reasons to take action for heat adaptation. From a critical overview of recent urban plans in Chinese cities, Ng and Ren (2018–this issue) conclude that for the efforts to materialise, firstly, there is a need for urban data; secondly, there is a need for having a cross disciplinary impact assessment; and thirdly, there is a need for developing a market and policy transformation mechanism. Many other contributions during the conference, coming from fields ranging from meteorological and risk modeling to sociology, allowed for fruitful exchanges among participants on governance, regulations, risks and decision support tools.

## 4. Conclusion

ICUC-9 was the largest ICUC held to date, reflecting the increased interest in climate and meteorology at the urban scale by the research community. The selection of articles in this special issue represents the breadth of research presented at ICUC-9 and helps point towards areas of future urban climate research. More planners,

social scientists and scientists from outside the 'pure' discipline of urban climate were present than during previous editions, allowing the rise of new themes as interdisciplinary and transfer to urban planners.

As the percentage of urban residents increases worldwide and cities face the challenge of both adapting to and assisting in the mitigation of large scale climate change, the motivation for the study of urban climates has never been greater.

## Acknowledgements

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