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Editorial

ICUC-7 Urban Climate Special Issue

The world's population lives in an increasingly urbanized world. The current generation is the first where more people live in cities than in rural areas (United Nations, 2010). Much of the urban growth is taking place in Asia where the urban transition now underway involves a volume of population much larger than in any other region in the world and is taking place on a scale unprecedented in human history. Demographic projections show that by 2025, 16 of the world's 29 megacities (cities with more than 10 million people) will be located in Asia, many of which have very basic problems in terms of environmental quality (Asian Development Bank, 2008). Cities have a direct impact on the local climate and also impact and are affected by climate change in many ways and at many scales. The continued growth of urban populations means that most people experience weather and climate that is significantly different from that of undeveloped, natural areas. Cities also affect the regional and global climates through the emission of air pollutants and the consumption of about three-quarters of the world's energy, releasing vast quantities of the greenhouse gases (GHGs) that are thought to warm the planet. Cities further have an important role to play in mitigating climate change but at present, climate action often dismisses effective local (city-scale) actions in favor of international announcements and prospective efforts (e.g. in terms of cutting GHG emissions).

Our scientific understanding of urban climates has advanced substantially over the past two decades including improved conceptualization, field observations, analysis of processes and model building. This Special issue of the *International Journal of Climatology* has been put together to highlight some of the research currently being undertaken in urban climatology. The papers were selected from the wide range of cutting edge research in urban climate presented at the *Seventh International Conference on Urban Climate* (ICUC-7), held in Yokohama, Japan, from 29 June to 3 July 2009. This conference, organized by the *International Association for Urban Climate* (IAUC), is part of a series of similar urban climate conferences which first started in Kyoto, Japan, in 1989 and take place about every 3 years. ICUC conferences provide an international forum where the world's urban climatologists can meet to showcase their research and discuss modern developments in the application of climatic knowledge to the design of better cities. About 330 people from 36 countries attended ICUC-7. Two hundred and sixteen oral presentations were delivered and 222 posters exhibited, covering a spectrum of urban climate issues ranging from pollutant transport to human thermal perception as part of two streams of parallel sessions on *physical processes in urban areas* and *applied urban climatology*, respectively. Extended abstracts of the presentations can be found at http://www.ide.titech.ac.jp/~icuc7/extended_abstracts/index-web.html. The 12 papers included in this Special issue illustrate the diversity in research. Three of the papers were presented as invited plenary lectures by leading researchers (Fujibe, Ashie and Kono, and Sailor). The other nine papers were selected from the oral presentations as examples of contemporary urban climate research on urban measurements (Stewart, Frey *et al*., Pawlak *et al*.), modeling (Grimmond *et al*., Chen *et al*., Rasheed *et al*.) and application of urban climate data (Lin *et al*., Dousset *et al*., Thorsson *et al*.).

The first paper in this issue reviews urban warming studies in Japan (Fujibe, 2011). Analysis of data from a dense nation-wide monitoring network shows that recorded temperatures increase a few degrees per century. An urban bias is present in recent temperature trends which is not limited to large cities but can also be detected at less urbanized sites. The paper stresses the need for a careful assessment of temperature records used for the evaluation of warming trends and climate change. Ashie and Kono (2011) demonstrate the increasing capability of numerical models to predict small-scale urban processes covering entire cities. Wind and temperature fields are simulated with a CFD model using ~5 billion computational grid cells with a horizontal grid spacing of 5 m covering the 23 wards of Tokyo (Japan). The model is used to evaluate an urban redevelopment plan and illustrates the temperature mitigation potential of reducing the built-up area. Sailor (2011) provides a review of methods for estimating anthropogenic heat and moisture emissions in the urban environment and the associated anthropogenic impacts on the urban energy balance. The paper highlights some fundamental limitations of past approaches (e.g. most attempts focus on the sensible heat component thereby largely ignoring moisture emissions) and suggests a roadmap forward for including anthropogenic heat and moisture in modeling of the urban environment.

The three papers on observations discuss methodological issues and report *in situ* measurements of energy balance and carbon dioxide fluxes. A systematic review and scientific critique of heat island literature covering 190 studies from 1950–2007 by Stewart (2011) discouragingly concludes that nearly half of all urban heat island magnitudes reported in the sample do not meet the assessment criteria. Half of the studies fail to sufficiently control the confounding effects of weather, relief or time on the reported heat island magnitudes and three-quarters fail to communicate basic metadata. Frey *et al.* (2011) present rare *in situ* data of the urban energy balance for a hot and dry city (Cairo, Egypt). All key variables of the energy balance were measured using standard eddy covariance instrumentation in three typical microclimates: an urban, a suburban-agricultural, and a suburban-desert station. The purpose of these measurements was to measure ground-truth data for a remote sensing based energy balance study and the paper makes conclusions regarding the direct usage of the *in situ* flux data for input in models later applied to remote sensing data. Pawlak *et al.* (2011) present two years of continuous measurements of carbon dioxide fluxes carried out with the eddy covariance method in the densely built-up city centre of Łódź (Poland). The results show characteristic features in the diurnal and annual course of the carbon flux with generally positive fluxes which peak during the cold season, have higher values during the day and during weekdays.

Recent advances in urban climate modeling are considered by three papers. Grimmond *et al.* (2010) report initial results from Phase 2 of the 'International Urban Energy Balance Comparison Project'. A systematic evaluation of 32 urban land surface schemes reveals wide variations in the performance of the models for individual fluxes and no individual model performs best for all fluxes. Grimmond *et al.* conclude that as many models do not perform well across all fluxes there is need for caution in their application and users should be aware of the implications for applications and decision making. Chen *et al.* (2011) provide an overview of the coupled WRF/urban modeling system as a community tool to address urban environmental issues. They discuss the daunting challenges of initializing the coupled model and of specifying the potentially vast number of parameters required for its execution. The ability of WRF/urban to capture urban heat islands, complex boundary-layer structures aloft, and urban plume transport and dispersion is demonstrated for several major metropolitan regions using recent applications. Rasheed *et al.* (2011) test the assumption shared by most urban parameterizations that a city is made up either of a regular array of parallelepipeds or of infinitely long canopies. The effects of complexity in urban geometry are investigated in relation to spatially averaged drag forces and shortwave radiation exchange. A new approach for fitting an array of cubes to any complex (realistic) geometry is subsequently suggested, so that new or existing urban parameterization schemes can be used with confidence.

Applications of urban climate research in the form of human thermal comfort and heat stress studies are represented by three papers. Lin *et al.* (2011) examine the effect of thermal adaptation on seasonal outdoor thermal comfort using 1644 interviews with concurrent micrometeorological measurements conducted outdoors in central Taiwan. The study confirms the effect of thermal adaptation on seasonal outdoor thermal comfort and demonstrates the limitation of thermal indices based exclusively on a heat-balance analysis of the human subjects in predicting their thermal preferences. Analysis reveals that people's thermal perceptions were strongly related to the air temperature and mean radiant temperature, but not significantly to wind speed and humidity. Dousset *et al.* (2011) present a study which documents the satellite monitoring of the August 2003 nine-day heat wave over the Paris metropolitan area. The thermal images show contrasting nighttime and daytime heat island patterns which are related to surface characteristics and land uses. The results confirm the influence of nocturnal temperatures on heat wave intensity, heat stress and excess mortality, and show the contribution of urban heat islands in intensifying the heat wave by absorbing heat during the day and progressively raising minimum nocturnal temperatures. The study reported by Thorsson *et al.* (2011) explores the influence of urban geometry on potential changes in outdoor thermal comfort due to climate change in a compact mid-rise high-latitude city (Gothenburg, Sweden). The results show that large intra-urban temporal variations exists for mean radiant temperature (T_{mrt}) as a result of urban geometry. Densely built structures are shown to mitigate extreme swings in T_{mrt}, improving outdoor comfort conditions both in summer and in winter. The relationship between the increase in daytime T_{mrt} and air temperature is found to be non-linear for their selected climate change scenario. The authors highlight the importance of including information on either T_{mrt} or thermal comfort in climate change scenarios to describe the combined effects of changes in multiple climate variables and to more realistically measure the impact on humans.

There is little doubt that urban climate issues will grow in significance in the coming decades. High quality, innovative research in urban climate is necessary to help mitigate against many of the most potent current environmental issues occurring in urban areas resulting from degradation of urban air quality and climate change. The papers included in this Special issue address some of the gaps in existing knowledge as identified below (from Grimmond *et al.*, 2010):

(i) Implications of global climate change for cities have not been adequately assessed to date. Potential impacts of global climate change on cities are not well known. More research on the interactions between global and urban climate change and the incorporation of urban land surface schemes into global climate models are needed (see Chen *et al.*, 2011; Fujibe, 2011; Grimmond *et al.*, 2010).

(ii) In terms of air pollution and health, there is a need to improve short-range, high-resolution numerical prediction of weather, air quality and chemical dispersion in the urban zone. There is also a need for model studies of wind and pollutant transport in complex urban geometries and those which include the combined effects of wind and buoyancy (see Ashie and Kono, 2011; Rasheed *et al.*, 2011).

(iii) Urban climate information is not being translated effectively into the design and construction of more sustainable cities. Issues here concern communication between researchers with different backgrounds and between researchers and planners or architects. There is also a lack of tools to assist in climate-sensitive design (see Dousset *et al.*, 2011; Lin *et al.*, 2011; Thorsson *et al.*, 2011).

(iv) The lack of appropriate data is a major obstacle in providing suitable urban climate information to address the various knowledge gaps. Operational urban measurement station and networks, especially in rapidly developing cities in hot climates and in their surroundings are needed. Vertical profiles of physical and chemical variables should be sampled and long term measurement stations should be preserved or established in cities with different urban morphologies to determine universal flow and flux characteristics (see Frey *et al.*, 2011; Pawlak *et al.*, 2011, Sailor, 2011; Stewart, 2011).

Despite the progress made so far more research is still needed to improve understanding to match that acquired for other environments. Many of these new findings will be presented at the next IAUC conference (ICUC-8) which will be held in Dublin, Ireland from 6–12 August, 2012 (www.icuc8.org). The Guest Editors of this Special issue wish to thank the contributors, the reviewers and the publishers.

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References

Ashie Y, Kono T. 2011. Urban-scale CFD analysis in support of a climate-sensitive design for the Tokyo Bay area. *International Journal of Climatology* **31**: 74–188. DOI: 10.1002/joc.2226.

Asian Development Bank. 2008. *Managing Asian Cities: Sustainable and inclusive urban solutions*. Mandaluyong City, Philippines: Asian Development Bank.

Chen F, Kusaka H, Bornstein R, Ching J, Grimmond CSB, Grossman-Clarke S, Loridan T, Manning KW, Martilli A, Miao S, Sailor D, Salamanca FP, Taha H, Tewari M, Wang X, Wyszogrodzki AA, Zhang C. 2011. The integrated WRF/urban modelling system: development, evaluation, and applications to urban environmental problems. *International Journal of Climatology* **31**: 273–288. DOI: 10.1002/joc.2158.

Dousset B, Gourmelon F, Laaidi K, Zeghnoun A, Giraudet E, Bretin P, Mauri E, Vandentorren S. 2011. Satellite monitoring of summer heat waves in the Paris metropolitan area. *International Journal of Climatology* **31**: 313–232. DOI: 10.1002/joc.2222.

Frey CM, Parlow E, Vogt R, Harhash M, Mohammad M, Wahab, A. 2011. Flux measurements in Cairo. Part 1: *in situ* measurements and their applicability for comparison with satellite data. *International Journal of Climatology* **31**: 218–231. DOI: 10.1002/joc.2140.

Fujibe F. 2011. Urban warming in Japanese cities and its relation to climate change monitoring. *International Journal of Climatology* **31**: 162–173. DOI: 10.1002/joc.2142.

Grimmond CSB, Roth M, Oke TR, Au YC, Best M, Betts R, Carmichael G, Cleugh H, Dabberdt W, Emmanuel R, Freitas E, Fortuniak K, Hanna S, Klein P, Kalkstein LS, Liu CH, Nickson A, Pearlmutter D, Sailor D, Voogt J. 2010. Climate and More Sustainable Cities: Climate Information for Improved Planning and Management of Cities (Producers/Capabilities Perspective). *Procedia Environmental Sciences* **1**: 247–274.

Grimmond CSB, Blackett M, Best MJ, Baik J-J, Belcher SE, Beringer J, Bohnenstengel SI, Calmet I, Chen F, Coutts A, Dandou A, Fortuniak K, Gouvea ML, Hamdi R, Hendry M, Kanda M, Kawai T, Kawamoto Y, Kondo H, Krayenhoff ES, Lee S-H, Loridan T, Martilli A, Masson V, Misao S, Oleson K, Ooka R, Pigeon G, Porson A, Tyu Y-H, Salamnca F, Steeneveld GJ, Tombrou M, Voogt JA Young DT, Zhang N. 2010. Initial Results from Phase 2 of the International Urban Energy Balance Comparison Project. *International Journal of Climatology*. DOI: 10.1002/joc.2227.

Lin TP, de Dear R, Hwang R-L. 2011. Effect of thermal adaptation on seasonal outdoor thermal comfort. *International Journal of Climatology* **31**: 302–312. DOI: 10.1002/joc.2120.

Pawlak W, Fortuniak K, Siedlecki M. 2011. Carbon dioxide flux in the centre of Łódź, Poland – analysis of a two-year eddy covariance measurements data set. *International Journal of Climatology* **31**: 232–243. DOI: 10.1002/joc.2247.

Rasheed A, Robinson D, Clappier A, Narayanan C, Lakehal D. 2011. Representing complex urban geometries in mesoscale modeling. *International Journal of Climatology* **31**: 289–301. DOI: 10.1002/joc.2240.

Sailor D. 2011. A review of methods for estimating anthropogenic heat and moisture emissions in the urban environment. *International Journal of Climatology* **31**: 189–199. DOI: 10.1002/joc.2106.

Stewart ID. 2011. A systematic review and scientific critique of methodology in modern urban heat island literature. *International Journal of Climatology* **31**: 200–217. DOI: 10.1002/joc.2141.

Thorsson S, Lindberg F, Björklund J, Holmer B, Rayner D. 2011. Potential changes in outdoor thermal comfort conditions in Gothenburg, Sweden due to climate change: the influence of urban geometry. *International Journal of Climatology* **31**: 324–335. DOI: 10.1002/joc.2231.

United Nations. 2010. World Urbanization Prospects, the 2009 Revision: Highlights. New York, United Nations, Department of Economic and Social Affairs, Population Division (available at: http://esa.un.org/unpd/wup/doc_highlights.htm, last accessed 19 October 2010).

