Urban Climate and the Tropical City

Professor Matthias Roth

The majority of urban climate research to date has focused on North American and European cities located in temperate climates in the Northern hemisphere. In contrast a similar body of work and therefore understanding in the (sub) tropical context is not readily available. The paper gives a brief overview of the current understanding of climates in low-latitude cities. Energy balance, heat island and carbon exchange are research areas that will be covered and results will be compared with data from temperate climate zones. As will be shown the available work is biased towards descriptive studies rather than process work that seeks to indicate the physical climatology. There are strong reasons why (sub)tropical urban climate studies deserve a heightened profile in the scientific research community. Heat islands have practical implications for health, air quality and design and are directly linked to global climate concerns. The anthropogenic carbon dioxide contribution by these rapidly growing cities needs to be quantified, though direct measurements have only started recently.

Lessons learnt from Urban Energy Balance Models Evaluations

Professor Sue Grimmond

Urban surface energy balance models are used to simulate urban exchanges for a wide range of applications by meteorologists, engineers, architects, planners and policy makers. These models vary greatly in terms of their complexity and the processes they parameterize. Here an overview of the types of models will be presented and key results from an international comparison project to evaluate urban land surface schemes along with more detailed analysis of some individual models. These will be used to consider the questions such as:

What are the important processes to model?
What information about the surface is it necessary to know?
How can the surface best be described in terms of land use/cover classes?
What type of model performs best?
Does model performance vary through the year?
What are the implications of these questions for model users and decision makers?

The overall goal of this lecture is to provide an overview of the state-of-the-art urban climate modeling with guidance on key questions that should be asked of modelers so users can best interpret model results.

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Heat Island Mitigation Techniques

Professor M. Santamouris

Heat Island Mitigation Techniques aim to amortise the phenomenon and counterbalance the impact of temperature increase.

Mitigation techniques aim to manage the strength of sources and sinks participating in the thermal balance of the urban environment. In particular to increase the strength of heat sinks and decrease the one of heat sources. Heat mitigation techniques have been seriously developed during the recent period. Many applications aiming to improve local microclimate and amortise heat island, have been designed and implemented quite recently with high success

The specific lectures will present the thermal balance in urban environment and analyse each term. Then the main mitigation techniques will be presented. The main characteristics of the principal technologies will be analysed. The state of the art on the existing industrial products will be analysed. Methods to design the various mitigation techniques will be shown. Examples of successful applications will be presented.

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Lessons learnt from Urban Human-Biometeorology of Urban Areas in Central Europe

Professor Helmut Mayer

For Central Europe, patterns of urban structures and citizens are not adapted to regional climate change, which is characterized by trends of climate variables (e.g. increase of near-surface air temperature) and extreme weather (e.g. heat waves). Therefore, urban climate develops more and more to a planning factor of continuously rising significance. However, a prerequisite is that results on urban climate meet the demands of urban planning, e.g. their direct reference to citizens. This leads to the fundamental question of urban human-biometeorology: how can processes and phenomena of urban climate be evaluated in a way that is relevant to citizens? In human-biometeorology, assessment methods for both the thermal and air pollution component of urban climate were developed. In the meantime, they were successfully tested for different urban environments. Therefore, they can be routinely applied in investigations on urban climate related to sustainable urban planning.

The overall goal of this lecture is to provide an overview of the state-of-the-art urban human-biometeorology. For this interdisciplinary field of meteorology, the students should learn (i) key questions, (ii) different investigation methods, (iii) options to present results, and (iv) application of urban human-biometeorological results in urban planning.

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Analysis of Microclimate and Human Thermal Comfort in Urban Areas

Professor Akashi Mochida

Human thermal sensation is determined by the heat balance of human body exposed to microclimate at pedestrian level. The microclimate at pedestrian level in urban areas is characterized by three-dimensional turbulent airflow and heat transports around buildings including the effects of multi-reflections of short-wave and long-wave radiations. To make strategies of urban planning and building design for mitigating the impacts of urban heat island on human thermal sensation in outdoor space, the structures of the complex turbulent flows and the heat transports around buildings including the influences of small scale obstacles existing within real streets, such as trees, cars, crowds, etc. must be known. The microclimate analysis based on CFD technique can be a powerful tool for this purpose if it is properly used. But, in many practical applications, only beautiful visualizations of simulation results are shown.

The overall goal of this lecture is to provide an overview of the current status and remaining issues of the microclimate analysis based on CFD, and hence discuss the way how the microclimate analysis can be appropriately applied to the control and design of urban environment in high-density Asian cities.

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Thermal Comfort in the Urban Climatic Environment

Professor Richard de Dear

Comfort perception of the thermal environment has been a distinct research focus of engineering and architecture disciplines for almost a century research and much of what is known about this topic has been applied to indoor environments in the form of heating, ventilation and air-conditioning standards and bioclimatic design guides. Extension of the enquiry to outdoor settings, particularly the urban context, is less well developed for the simple reason that there is not much that engineers or urban designers can do to ameliorate comfort outdoors. But in climate zones on at the margin of discomfort even slight attenuation of urban climatic parameters may be enough to restore thermal comfort. So in the last decade we've witnessed a growth of research effort on these questions from disciplines as diverse as biometeorology, engineering, architecture, urban design and planning. This lecture lays the foundation of thermal comfort in the outdoor urban climatic context by addressing the following questions:

What do we know about physics and physiological underpinnings of thermal comfort in the indoor context?
How does the psychological construct of comfort relate to the physiologically regulated heat balance of the human body?
How has this knowledge been formulated into numerical models of thermal physiology and comfort?
How are these models expressed in thermal comfort standards?
What are the challenges involved in extending thermal comfort research into outdoor urban settings?

The overall goal of this lecture is to provide a fundamental understanding of the science of thermal comfort with particular attention to the implications for urban design and planning.

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Some 60% of the planetâ€™s expected urban area by 2030 is yet to be built. This forecast highlights how rapidly the worldâ€™s people are becoming urban. Cities now occupy about 2% of the worldâ€™s land area, but are home to about 55% of the worldâ€™s people and generate more than 70% of global GDP, plus the associated greenhouse gas emissions. So what does this mean for people who live in the tropical zones, where 40% of the worldâ€™s population lives? On current trends, this figure will rise to 50% by 2050. With tropical economies growing some 20% faster than the rest of the world, the result is a swift expansion of tropical cities. Population and number of cities of the world, by size class, 1990, 2018 and 2030. City scale urban climate modelling of Greater Kuala Lumpur by ADMS-Urban. ADMS-Urban (previously ADMS-T&H) has been widely used to study the urban climates on a city scale (e.g. Maggiotto et al. 2014; Mavrogianni et al. 2011) as well as on a neighbourhood/street scale (e.g. Hamilton et al. 2014; Aktas et al. 2017). In this study, city scale urban climate modelling of Greater Kuala Lumpur has been performed.Â Climatic factors include both poor dispersion due to low wind speeds, and the larger amount of latent heat due to more frequent and intense precipitation. Kuala Lumpur also experiences increased anthropogenic heat due to larger traffic loads and air conditioning use, which generate extra challenges in the modelling of this and similar tropical urban climates. Tropical climate is one of the five major climate groups in the KÃ¶ppen climate classification. Tropical climates are characterized by monthly average temperatures of 18 â„ƒ (64.4 â„‰) or higher year-round and feature hot temperatures. Annual precipitation is often abundant in tropical climates, and shows a seasonal rhythm to varying degrees. There are normally only two seasons in tropical climates, a wet season and a dry season. The annual temperature range in tropical climates is normally very small... Classical urban climatology studies have shown that UHIs are essentially defined by the temperature differences between downtown areas and the rural environment or peripheral areas with low built density [1,2,3,4,5]. Especially in tropical environments, urban areas are sometimes occupied by poor thermally insulated construction.Â In a rural environment, low built densities and the presence of arboreal, shrub, and bush vegetation speeds up heat loss to upper atmospheric levels, especially at night. Studies performed in both tropical [6,7,8,9,10,11,12,13,14,15] and temperate climates [1,16,17,18,19], demonstrate that the highest intensity of heat islands form under the influence of stable anticyclonic atmospheric systems.