2022 IAUC Virtual Poster Session

Conference Abstract book

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Keynote #1:

Urban climate justice - interdisciplinary solutions for equitable outcomes

30th August 05:00-06:30 UTC

Dr Gina Ziervogel[1] and Dr. Chandni Singh[2]
[1]Department of Environmental and Geographical Science, University of Cape Town, Cape Town, South Africa, [2]School of Environment and Sustainability, Indian Institute for Human Settlements (IIHS), Bangalore, India

Abstract

Climate justice seeks to investigate and protect at-risk populations who are disproportionately affected by climate change. The concentration of people, assets and infrastructure mean that cities are vulnerable to climate justice inequities. Further, climate change is likely to exacerbate existing social vulnerabilities. This keynote session will discuss risks associated with urban climate challenges and multidisciplinary approaches to addressing urban climate justice.

Author Bio

Gina Ziervogel: Prof. Gina Ziervogel is Associate Professor in the Department of Environmental and Geographical Science at the University of Cape Town, South Africa. Her research focuses on climate change adaptation and development across scales from the household to municipal level with a focus on water, urban governance, and resilience issues. Methodologically she is interested in engaged scholarship and transdisciplinary projects that bring together civil society, government, and academics to address problems collaboratively. She was a lead author on the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment report, Cities, settlements, and key infrastructure chapter and has authored numerous papers, book chapters and popular articles. In 2020 Gina was awarded the UCT Social responsiveness award.

Chandni Singh: Dr. Chandni Singh is a Senior Researcher at the School of Environment and Sustainability, at the Indian Institute for Human Settlements, Bangalore. She works at the interface of climate change adaptation, livelihood transformations, and rural and urban development. Her work focusses on understanding differential vulnerability to climate change, the barriers and enablers to adaptation, and inclusive migration and displacement, with a regional focus on South Asia. She is Coordinating Lead Author on Adaptation Effectiveness for UNEP's Adaptation Gap Report 2022 and Lead Author on the IPCC 2022 Assessment Report 6, Chapter 10 on 'Asia'. Chandni currently serves on the Science Committee for Adaptation Futures 2023 and on the editorial boards of Regional Environmental Change, Urbanisation, and WIREs Climate Change. She strongly believes in teaching, mentoring, and practicing inclusive, decolonial research anchored in theory and practice from the Global South.

Session Theme: Urban Climate Justice

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Keynote #2:

Heat health in the built environment

31st August 10:00-11:30 UTC

Prof. Jason K.W. Lee[1] and Dr. Clare Heaviside[2]
[1]Department of Physiology, Yong Loo Lin School of Medicine, National University of Singapore (NUS), Singapore, [2]Bartlett School of Environment, Energy & Resources, University College London (UCL), London, United Kingdom

Abstract

Extreme temperatures cause more deaths than any other extreme weather event. The excess heat in cities, as well as the larger concentration of people and economic activities, make the urban population particularly vulnerable to health risks due to heat. This keynote panel will engage experts in heat health analyses and discuss future pathways for adaptation and mitigation of this grave concern.

Author Bio

Jason K.W. Lee: Prof. Jason Lee obtained his first degree (Sports and Exercise Science – 1st Class Honours) from Loughborough University, UK. Following the award of G V Sibley Memorial Prize, he stayed on to complete a PhD in Exercise Physiology under sponsorship from the UK Overseas Research Scholarship. Jason is a Fellow of the American College of Sports Medicine. Jason completed his 12-year tenure at the DSO National Laboratories in 2018 by directing the Human Performance Programme in his final appointment. He co-leads the Human Potential Translational Research Programme and is the Founding Director for the new Heat Resilience and Performance Centre at NUS. He is a member of the WHO and WMO Report on Climate Change on Workers' Health and Productivity. Jason chairs the Scientific Committee on Thermal Factors at the International Commission on Occupational Health and is on the management committee at the Global Heat Health Information Network.

Clare Heaviside: Dr Clare Heaviside is a NERC Independent Research Fellow and Associate Professor. Her research is multi-disciplinary and covers climate change health impacts, air pollution, and urban climate. Clare's background is in meteorology and atmospheric physics, and she also worked in the public health sector for almost a decade, becoming head of Climate Change at Public Health England in 2017, before joining Oxford University and now UCL. Clare is interested in how changes to the environment affect health, e.g., direct heat-related health impacts associated with the urban heat island, and how we might mitigate some of these impacts through adaptation measures. She has worked on quantifying temperature related mortality for current and projected future climate scenarios in different parts of the world using climate data and regional climate models. She also works on quantifying impacts of air pollution on health, using measured and modelled pollutant concentrations combined with health data.

Session Theme: Biometeorology and Health

Keynote #3:

Urban Climate Informatics - An emerging direction in urban climate research

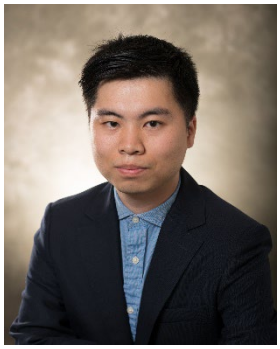
01st September 15:00-16:30 UTC

Dr. Ariane Middel[1, 2] and Dr. Zhonghua Zheng [3]
[1]School of Arts, Media and Engineering, [2]School of Computing and Augmented Intelligence, Arizona State University, United States, [3] National Center for Atmospheric Research (NCAR), Colorado, United States

Abstract
Urban climate informatics is an evolving research field that takes advantage of four technological trends to answer contemporary climate challenges in cities: advances in sensors, improved digital infrastructure (e.g., cloud computing), novel data sources (e.g., crowdsourced, or big data), and leading-edge analytical algorithms and platforms (e.g., machine learning, deep learning). This keynote session will discuss the emerging trends in UCI and directions in addressing urban climate challenges using novel modelling analytics.

Author Bio

Ariane Middel: Dr. Ariane Middel is an Assistant Professor in the School of Arts, Media and Engineering and the School of Computing and Augmented Intelligence at Arizona State University, USA. Her research focuses on climate-sensitive urban form, design, landscapes, and infrastructure in the face of extreme heat and climatic uncertainty. She directs the SHaDE Lab, which explores the “hot” topic in three dimensions: heat as it can be sensed by instruments; heat as it is experienced by humans; and heat as it can be modelled using microclimate simulations and urban climate informatics methods. She is the recipient of an NSF CAREER award on “Human Thermal Exposure in Cities” and the President-elect of the IAUC (2022-2026). She also currently serves on the Board of the American Meteorological Society (AMS) Built Environment and is a member of the International Society of Biometeorology (ISB).



Zhonghua Zheng: Dr. Zhonghua Zheng is an Advanced Study Program (ASP) Postdoctoral Fellow at the National Center for Atmospheric Research (NCAR). His research interests include (1) environmental data science, (1) urban climate and environment, and (3) air quality and aerosol properties. He earned a Ph.D. in Environmental Engineering in Civil Engineering with a concentration in Computational Science and Engineering from the University of Illinois at Urbana-Champaign (UIUC). Dr. Zheng was a Data Scientist Intern at Bayer for three years, primarily working for The Climate Corporation, and an ORISE Ph.D. Intern/Researcher at Oak Ridge National Laboratory (ORNL), working with National Center for Computational Sciences - Advanced Data and Workflow Group. He was an invited participant for the Atmospheric Chemistry Colloquium for Emerging Senior Scientists (ACCESS XVI) and a member of the 2022 class for the American Meteorological Society’s Early Career Leadership Academy (ECLA).

Session Theme: Urban Climate Informatics

I

ECR session #1:

Preparing Research Funding and Fellowship Proposals

30th August 10:00-12:00 UTC

Dr. Csilla Gál[1], Dr. Marialena Nikolopoulou[2], Dr. Chao Ren[3]

[1]Dalarna University, Dalarna, Sweden; [2]University of Kent, Canterbury, UK; [3]University of Hong Kong

Abstract

Urban climate is an interdisciplinary scientific field with topics that span the theoretical and abstract science to applied, use-inspired research. As such, sources of funding and support for research can come from a disparate array of sources. Join us as researchers discuss their experiences in searching, finding, applying, and receiving grant support for urban climate research across the globe.

Objectives

- Discuss personal experiences in searching out funding sources and opportunities.
- Share what kinds of sources might be useful for ECRs to know about (particularly those geared toward under-represented minorities)
- Develop a database where we can provide information about various funding sources to support the ECRs in urban climate across the globe.

Session Themes

Professional development; Early career research

II

ECR session #2:

Justice, Equity, Diversity, and Inclusion in Urban Climate Research Community

31th August 15:00-17:00 UTC

Dr. Ifeoluwa Balogun[1], Dr. Tania Sharmin[2], Dr. J. Marshall Shepherd[3]

[1]Federal University of Technology, Akure, Akure, Nigeria; [2]Cardiff University, Cardiff, UK; [3]University of Georgia, Athens, Georgia, USA

Abstract

As climate justice becomes more and more prominent, a question we must ask as a community is how do we encourage and support under-represented minority individuals as they pursue careers in urban climate? Panellists will discuss their experiences of navigating the urban climate scientific landscape and share means of encouraging future generations of urban climate researchers with a diversity of experiences and backgrounds.

Objectives

- Discuss the obstacles that under-represented minority individuals face and how we (individually and collectively in our discipline) can support them.
- Begin to explore and consider tangible means of support going forward

Session Themes

Equity, diversity, and inclusion (EDI); Professional development; Early career research

III

ECR session #3:

Preparing CV for Various Industries in Urban Climate

01st September 05:00-07:00 UTC

Dr. Charmaine Franklin[1], Dr. Matthias Roth[2], Dr. Leena Järvi[3]

[1]Australia Bureau of Meteorology, Victoria, Australia; [2]National University of Singapore, Singapore; [3]University of Helsinki, Helsinki, Finland

Abstract
While every person's experience and strengths are unique, there are methods for structuring CVs for academic, government, and private industry/consulting that accentuate your skills. Hear from researchers about what they include or look for in CVs for these three sectors that support urban climate research.

Objectives

- Discuss the structures of good/strong CVs in the panellists' sector.
- Talk about various expectations of job materials between academia and industry/government.
- Consider what are the key points or questions that should be addressed by CVs and other job materials
- Create some templates of CV (and/or other job application materials) for ECRs to take and make their own.

Session themes

Professional development, Early career research

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The impact of the COVID-19 pandemic on air pollution: A global assessment using machine learning techniques

Dr Kerry A Nice ORCID iD
University of Melbourne, Melbourne, Australia

Abstract

In response to the COVID-19 pandemic, most countries implemented public health ordinances that resulted in restricted mobility and a resultant change in air quality. This has provided an opportunity to quantify the extent to which carbon-based transport and industrial activity affect air quality. In this study, confounding factors were disentangled for a direct comparison of pandemic-related reductions in absolute pollutions levels, globally. The non-linear relationships between atmospheric processes and daily ground-level NO2, PM10, PM2.5 and O3 measurements were captured in city- and pollutant-specific XGBoost models for over 700 cities, adjusting for weather, seasonality and trends. City-level modelling allowed adaptation to the distinct topography, urban morphology, climate and atmospheric conditions for each city, individually, as the weather variables that were most predictive varied across cities. Pollution forecasts for 2020 in absence of a pandemic were generated based on weather and formed an ensemble for country-level pollution reductions. Findings were robust to modelling assumptions and consistent with various published case studies. NO2 reduced most in China, Europe and India, following severe government restrictions as part of the initial lockdowns. Reductions were highly correlated with changes in mobility levels, especially trips to transit stations, workplaces, retail and recreation venues. Further, NO2 did not fully revert to pre-pandemic levels in 2020. Ambient PM2.5 pollution, which has severe adverse health consequences, reduced most in China and India. Increased O3 levels during initial lockdowns have been documented widely. However, our analyses found a subsequent reduction in O3 for many countries below what was expected based on meteorological conditions during summer months (e.g., China, United Kingdom, France, Germany, Poland, Turkey). The effects in periods with high O3 levels are especially important for the development of effective mitigation strategies to improve health outcomes.

Session Themes

Special Session: COVID/pandemic lock-down: Impact of COVID/pandemic lock-down measures on Urban Climate, Air Quality, and Human Life

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Building-resolved simulations with the urban microscale model PALM-4U for case studies in Vienna, Austria

Dr. Maja Zuvela-Aloise, M.Sc. Brigitta Hollosi, Dr. Claudia Hahn
ZAMG, Vienna, Austria

Abstract

The newly developed Parallelized Large-Eddy Simulation Model for Urban Applications (PALM-4U) has been applied for the city of Vienna to explore its potential to support urban planning processes in different applicational settings, such as planning of open spaces on a district level or optimization of building projects by evaluating influence of vegetation, especially trees.

The simulations were carried out in three areas of the city differing in morphology and with variable spatial resolution varying between 1 – 10 m. The selected model domains represent dense built-up environment and mixed-residential areas in complex terrain. The static data related to geographical information and urban infrastructure are based on 2- and 3-dimensional GIS data from the city of Vienna, available as spatial multi-purpose maps (Flächen-Mehrzweckkarte - FMZK), street tree cadastre, Digital Elevation Model and Digital Surface Model, which were combined with the national land cover data (Land Information System Austria - LISA) to account for the unresolved vegetation. The simulations were performed for a 3-day heat wave period in August 2018, starting each daily run at 06:00 UTC.

The results show that the microscale model PALM-4U is able to simulate atmospheric processes in urban regions in complex topography, giving plausible spatial patterns in temperature distribution as previously found in coarser scale model simulations and remote-sensing data. The comparison of model results for air temperature showed a good agreement with observations. However, strong dependence on input meteorological data and very high sensitivity to the choice of model configuration, especially for the model simulations with highest resolution was detected. The sensitivity experiments with changed land use, such as increase in sealed surfaces vs. vegetation showed an expected response with heating vs. cooling effect. Further model validation is needed to evaluate intensity of temperature variations and spatial patterns related to different urban structures.

Session Themes

Urban climate methods: Modelling

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A Global, High-Resolution Dataset of Urban Extreme Heat Exposure

Prof. Cascade P Tuholske
Montana State University, Bozeman, Montana, USA

Abstract

The Global High Resolution Daily Extreme Urban Heat Exposure (UHE-Daily), 1983-2016 data set contains a high-resolution, longitudinal global record of geolocated urban extreme heat events and urban population exposure estimates for more than 10,000 urban settlements worldwide for 1983-2016. Urban extreme heat events and urban population exposure are identified for each urban settlement in the data record for five combined temperature-humidity thresholds: two-day or longer periods where the daily maximum Heat Index (HI_{max}) > 40.6 °C; one-day or longer periods where HI_{max} > 46.1 °C; and one day or longer periods where the daily maximum Wet Bulb Globe Temperature ($WBGT_{max}$) > 28 °C, 30 °C, and 32 °C. The $WBGT_{max}$ thresholds follow the International Standards Organization (ISO) criteria for risk of occupational heat related heat illness, whereas the HI_{max} thresholds follow the U.S. National Weather Services' definition for an excessive heat warning. For each criteria, across urban settlements worldwide, the data set also contains the duration, intensity, and severity of each urban extreme heat event. This poster will overview the UHE-Daily dataset, including data development overview, access, and use cases.

Session Themes

Integrated assessments of urban climate : Urban climate vulnerability in developing countries

7

Evaluating the spatiotemporal variations of daytime surface and canopy urban heat islands: An arid climate case study

Ms Elham Shafieiyoun, Associate Professor Mehdi Khiadani
Edith Cowan University, Joondalup, Australia

Abstract

Analyzing and quantifying the urban heat island (UHI) phenomenon accurately are critical to adopt appropriate mitigation policies. In this study, the retrieved land surface temperature (LST) was employed to compute surface urban heat islands (SUHI) using the urban-rural LST difference and urban thermal field variance index (UTFVI). In addition to the available air temperature (AT) at a synoptic station near Isfahan city, Iran, in-situ AT was measured at three different urban sites and the canopy urban heat island (CUHI) was quantified based on the urban-rural AT difference. The seasonal comparison of the results demonstrated that the inverted SUHI intensity characterized by the LST difference was stronger in spring and summer as compared with fall and winter. However, the CUHI intensity computed by AT difference showed the opposite trend. The inverted SUHI intensity varied between -13.9°C in summer and -1.5°C in winter, while the hourly average CUHI intensity ranged between -4.4°C in summer and 6.3°C in autumn. The spatial variation of CUHI showed significant differences in the mean daytime UHI intensity between the urban sites ($p < 0.05$). The spatial variation of UTFVI indicated that a non-SUHI and the strongest SUHI were dominant phenomena in urban sites. In contrast, the computed values of SUHI intensity using LST difference were negative, representing only a non-SUHI phenomenon. The correlation between SUHI and CUHI values was not significant, indicating that the intensities of CUHI and corresponding SUHI are not comparable in arid climates. The results demonstrate that in arid climates, SUHI calculated using UTFVI and CUHI can provide detailed information about spatiotemporal variations of UHI. It is important to take these factors into consideration when comparing the SUHI and UHI intensity between different climates.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Urban climate changes during the COVID-19 pandemic: Integration of urban-building-energy model with social big data

Dr. Yuya Takane ORCID iD[1], Dr. Ko Nakajima ORCID iD[1], Prof. Yukihiro Kikegawa ORCID iD[2]
[1]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. [2]Meisei University, Tokyo, Japan

Abstract

The changes in human behaviour associated with the spread of COVID-19 infections have changed the urban environment. However, little is known about the extent to which they have changed the urban climate, especially in air temperature (T), anthropogenic heat emission (QF), and electricity consumption (EC). We quantitatively evaluated these effects using a unique method that integrates real-time human population data (social big data) with an urban climate model. The results showed that in an office district in the city centre of Tokyo, the biggest metropolis in the world, under a significantly reduced population, EC (CO2 emissions) would be 30% and QF would be 33% of pre-COVID levels (without the stay-at-home advisories). This resulted in a T decrease of about 0.2°C, representing about 20% of the past greenhouse gas-induced warming (about 1.0ºC) in Tokyo. This method can be benchmarked and then applied to worldwide. The results suggest that changes in human behaviour can represent an adaptation and decarbonizing strategies to climate change in cities.

Session Themes

Special Session: COVID/pandemic lock-down: Impact of COVID/pandemic lock-down measures on Urban Climate, Air Quality, and Human Life

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Evolution of the surface urban heat island in the Bangkok Metropolitan Region from 2000 to 2020

Professor Linlin Lu ORCID iD, Ms. Luyang Pan
Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing, China

Abstract

The Bangkok city has experienced tremendous increases in both population and built-up area expansion in recent decades. The urbanization process has transformed the city into the Bangkok Metropolitan Region (BMR), significantly intensifying surface urban heat island (SUHI) effects. Thermal infrared remote sensing data have been used to explore the characteristics of SUHI in the BMR. However, understanding the spatiotemporal evolution of the urban thermal environment is challenging due to the difficulty in obtaining long-term consistent remote sensing data of the cloud-prone landscape. In this study, the spatiotemporal data fusion algorithm was utilized to fill this gap and create high spatial resolution remote sensing data for each month in winter from 2000 to 2020. The remote sensing data was used to retrieve land surface temperature (LST) in the BMR. The temporal and spatial variations in surface urban heat island intensity (SUHII) were then captured using spatial cluster analysis. Finally, gradient analysis and geographically weighted regression (GWR) were employed to analyze the effects of land cover composition on LST. The results showed that the SUHI intensity increased from 4.40 ℃ in 2000 to 5.76 ℃ in 2020 in winter. The areal percentage of SUHI hot spots increased from 24.86% in 2000 to 29.13% in 2020. SUHI hot spots were concentrated in the urban core and eastern areas, and cold spots were distributed in the urban fringe and coastal areas. The gradient analysis results indicate that vegetation had a stronger effect on LST compared to the built-up area, while built-up land effects increased over time. The cooling effect of woodlands was more widely distributed than cultivated land. These results provide useful information for developing strategies to mitigate heat in metropolitan regions.

Session Themes

Integrated assessments of urban climate : Urban climate vulnerability in developing countries

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Exploring the triadic relation of urban form, wind, and air quality at street level: A case of City of London, UK

Kiran A. Apsunde ORCID iD[1], Emmanuel Rohinton ORCID iD[2], Julie (Ann) Futcher ORCID iD[3], Jose Duenas ORCID iD[4]

[1]Trinity College Dublin (TCD), Dublin, Ireland. [2]Glasgow Caledonian University (GCU), Glasgow, United Kingdom. [3]Urban Generation, London, United Kingdom. [4]Universidad de Huelva, Huelva, Spain

Abstract

This study investigates the triadic relation of urban form (UF), air quality (AQ) and the wind environment at street level in a dense setting of the City of London through a detailed characterisation of the urban form, wind simulation and statistical analysis in conjunction with AQ data observations for the period June – December 2018.

While there are a plethora of broad level indicators describing urban morphology and form at neighbourhood and city levels, this study has taken a detailed approach towards identifying the street level canyon and canopy related metrics that influence the urban wind environment and ambient air quality. While it has deployed a range of existing metrics, the study has also introduced a set of new parameters that may further aid in understanding the triadic relation.

For over 826 canyons mapped in the study area, the study has analysed about forty-two (42) urban form and morphological metrics to understand the influence of urban form on the wind environment. Additionally, for sixty-three (63) canyons with AQ observations, the study has explored sixty-four (64) wind and UF related metrics for their statistical significance as predictors of AQ using the exploratory regression approach. Out of the 42 metrics used to investigate the influence of urban form on wind pattern, twenty-two (22) exhibit a statistical significance of greater than 50%. Moreover, out of the 64 variables used towards investigating the role of wind and urban form metrics on AQ, ten (10) exhibit a statistical significance of greater than 50%.

Amongst the newly introduced parameters Canyon Normality, Topographic Openness, Global solar Radiation, Effective Frontal Area, Wind Effect, Node Exposure, and traffic Z-score exhibited strong influence on the wind environment and consequently, the ambient air quality.

The study also found that the statistical significance of the deployed UF metrics varies with changing canyon orientation.

Session Themes

Urban climate processes: Urban air quality

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LST and exoatmospheric albedo modifications assessment in Summer and Winter thermal periods: study case in Lisbon, using Landsat 8 dataset and LCZ.

Márcia AN Matias[1,2], Dr. António Lopes[1,2,3]

[1]Institute of Geography and Spatial Planning, Lisbon, Portugal. [2]Centro de Estudos Geográficos, Lisbon, Portugal. [3]Associated Terra Lab, Lisbon, Portugal

Abstract

As previously proven, land surface temperatures (LST) can affect the air temperature of the surrounding areas (Matias & Lopes, 2020), showing that is important to understand how land surface changes can affect urban warming. LST and surface reflectance are the most essential concepts in modeling land surface processes. LST variations in space and time, measured by satellite remote sensing can be used to understand when correlated with the Local Climate Zones (Stewart & Oke, 2012), the variation of LST within a period of time. In this work, Landsat 8 Collection 2 Surface Temperature images were used to assess the LST and exoatmospheric properties of the Local Climate Zones (LCZ) in Lisbon's Metropolitan Area, in two different periods: summer and winter. Data from Urban Atlas Copernicus was used to understand land surface use changes. The preliminary results show that Urban and Non-Urban LCZs in Lisbon present different patterns regarding LST. LCZ Compact Mix-Rise and Heavy Industry show high LST but a low range of values. Large Low-Rise, Open Mix-Rise and Sparsely also built present high surface temperatures, however, the range of values is much higher. Surface reflectance values show that urban and non-urban LCZ present low reflectance values, but the latter presents a higher range of values.

Session Themes

Integrated assessments of urban climate : Urban climate and climate change

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Urban summer shade under hot and arid conditions and the prospects of outdoor heat stress reduction: results of a large-scale monitoring campaign

Dr. Or Aleksandrowicz ORCID iD[1], Prof. David Pearlmutter ORCID iD[2], Dr. Soultana (Tanya) Saroglou ORCID iD[2]

[1]Technion - Israel Institute of Technology, Haifa, Israel. [2]Ben-Gurion University of the Negev, Beer Sheva, Israel

Abstract

Air temperature in urban areas has been traditionally used by researchers for assessing the intensity of urban heat, focusing on the existence of so-called "urban heat islands" in cities. Yet this focus on air temperature, which may have grown out of the relatively straightforward and simple nature of its measurement, may not reflect well spatial and temporal microscale climatic differences between adjacent intra-urban locations, especially during the hot season and under clear sky conditions. Under these conditions, the intensity of street-level daytime heat stress may be highly affected by the body's exposure to solar radiation. The question of how strong this effect is, though, is not easily explored by monitoring, since precise quantification of the thermal effect of solar radiation exposure depends on a relatively complex and intricate measurement setup.

This study set out to evaluate the correlation between exposure to solar radiation and significant increases in heat stress under summer conditions by using a mobile 6-direction radiometer monitoring setup that facilitated the collection of relatively large amounts of urban climatic records without compromising the accuracy of the results. In 15 disparate monitoring days during the summers of 2020 and 2021, we monitored daytime outdoor conditions in two cities of a hot and arid summer Mediterranean climate in Israel's Coastal Plain: 207 locations in Tel Aviv-Yafo and 100 locations in Kefar Sava. The analysis of the results indicated that during summer, solar exposure significantly increased heat stress according to three common thermal comfort indices. At the same time, monitoring showed that air temperature differences between two adjacent shaded and unshaded locations proved to be very small.

Session Themes

Urban climate methods: Observations

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Pedestrian-level gust wind flow and comfort around building arrays – influencing assessment on the pocket park

Mr. Jiading ZHONG[1], Prof. Jianlin LIU[1], Dr. Yueli XU[1], Dr. Junsong WANG[2], Mr. Guoming LIANG[1]
[1]College of Environmental Science and Engineering, Donghua University, Shanghai, China. [2]School of Architecture, State Key Lab of Subtropical Building Science, South China University of Technology, Guangzhou, China

Abstract

Congested urban forms deteriorate urban ventilation, causing the problem of poor wind comfort at pedestrian level. Pocket parks are small-scale open spaces for neighborhoods' recreations, and they have the potential to alleviate this problem in cities, while this is rarely quantitatively investigated. This study investigates the pedestrian-level wind (PLW) flows around building arrays, and the influences of pocket park and vegetation on the mean and the gust wind flows, and the wind comfort are further assessed. Steady-state Reynolds Averaged Navier-Stokes (RANS) simulations with the RNG k-ε turbulence model are used and validated with the benchmark experiments that give correlation coefficients above 0.80, including winds around a building array and trees. Results indicate that pocket park amplifies the mean and the gust flows in the streets under the perpendicular inflow wind and attenuates the flows under the oblique and the parallel inflow winds. Inside the pocket park, an outdoor shelter space is created for pedestrian to relax and gather when winds in the streets are overly high. In this case, the vegetation promotes wind comfort conditions for sitting. These findings provide evidence for quantifying the effect of pocket parks with and without vegetation in achieving a healthy outdoor open space.

Session Themes

Urban climate processes: Boundary layer and urban canopy layer processes

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A simple thermal model to estimate the urban energy stored in Mexico City

Dr Victor L Barradas ORCID iD[1], MSc Martin Bonifacio-Bautista ORCID iD[2]

[1]Instituto de Ecologia, Universidad Nacional Autonoma de México, Mexico City, Mexico. [2]Instituto de Ciencias Atmosfericas y Cambio Climatico, UNAM, Mexico City, Mexico

Abstract

The drastic change in land use in cities alters the energy balance, giving rise to the urban heat island (UHI) phenomenon. One of these alterations is the drastic change in the energy that is stored in the urban fabric (Q_S) since it can dispose of up to 50% of the net radiation (Q_N) in densely populated areas. A thermal model of energy stored in the urban fabric is presented, using air temperature and the thermal properties of the materials present in a given area in Mexico City, capable of estimating Q_S more easily than other models. The values generated by this model were compared with the values generated with other models such as the residual from the Eddy correlations method and the thermal mass scheme used in Marseille, France. The results given by the thermal model and residual Q_S in the Escandon district with $Q_N>0$ were compared, giving a high correlation ($r^2=0.71$). While in the Merced-Balbuena district Q_N and residual Q_S on average were 237 and 116.5 Wm^{-2}, the latter being 49% of Q_N, while the estimation of Q_S with the thermal model was 142 Wm^{-2}, being 60% of Q_N. Regarding the results in Marseille, a similar behavior to the thermal model results was shown. However, an analysis of root mean square error (RMSE) showed for the Marseille thermal mass scheme a value of 109 and 101 Wm^{-2} for the thermal model, with which it can be stated that this method is more efficient and simpler than the other models mentioned. It is necessary to continue with this type of studies in intertropical countries.
We thank PAPIIT, DGAPA for their support (IT200620).

Session Themes

Urban climate methods: Modelling

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Turbulence analysis in representative urban modules in Mexico City as a form to UHI mitigation

Doctor Monica Ballinas ORCID iD
LES, Facultad de Arquitectura, UNAM, Ciudad de Mexico, Mexico

Abstract

Building materials that make up the architectural elements of the city absorbs more short-wave radiation which is emitted in long-wave radiation to their surroundings. Urban energy dissipation is slower than rural areas, giving place to the urban heat island phenomenon (UHI). In Mexico City, UHI effect in the dry hot season increases energy consumption to cold buildings to get thermal comfort. UHI intensity can reach up to 10°C. Because of that, a series of numerical experiments using ANSYS Fluent model were developed to understand the behavior of the wind as a form of building heat load mitigation. Three representative sites (modules) of the urban fabric of Mexico City were chosen considering temperature intensities (hot spots) and construction materials. Results show that Santa Fe (SFE) registered ω velocities up to -4.0 m/s which aparently is outside of the average range, while Narvarte (N) registered a value of 7.0 m/s and 3.5 in Escandon (E). These values, in apperence are out of the range, showing in some way the magnitude of the effect due to aerodynamical resistence of the module. ω intensities were analized with ANOVA test. Having, a ω average high value in Narvarte (1.1 m/s), followed by Escandon with 0.59 m/s, SFE module shows the most low value (-1.4 m/s). These values indicate the turbulence grade, being SFE the highest value. Positive values indicate, air is rising and negative, air descending. However, is evidente that aerodynamic resistence in SFE is higher than the other modules. It is important to note, ω depends on the structure and construction materials or optical properties of each module. Is necessary considerer UHI mitigation in urban planning, making an adequately use of urban elements in modules arrangements generating greater heat exchange. MB thanks to DGAPA, UNAM for postdoc scholarship.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Kikayon 1.0: Bridging the microclimatic design gap using a parametric tool for designing and quantifying street-level outdoor shade

Dr. Or Aleksandrowicz ORCID iD, Arch. Ezra Ozery
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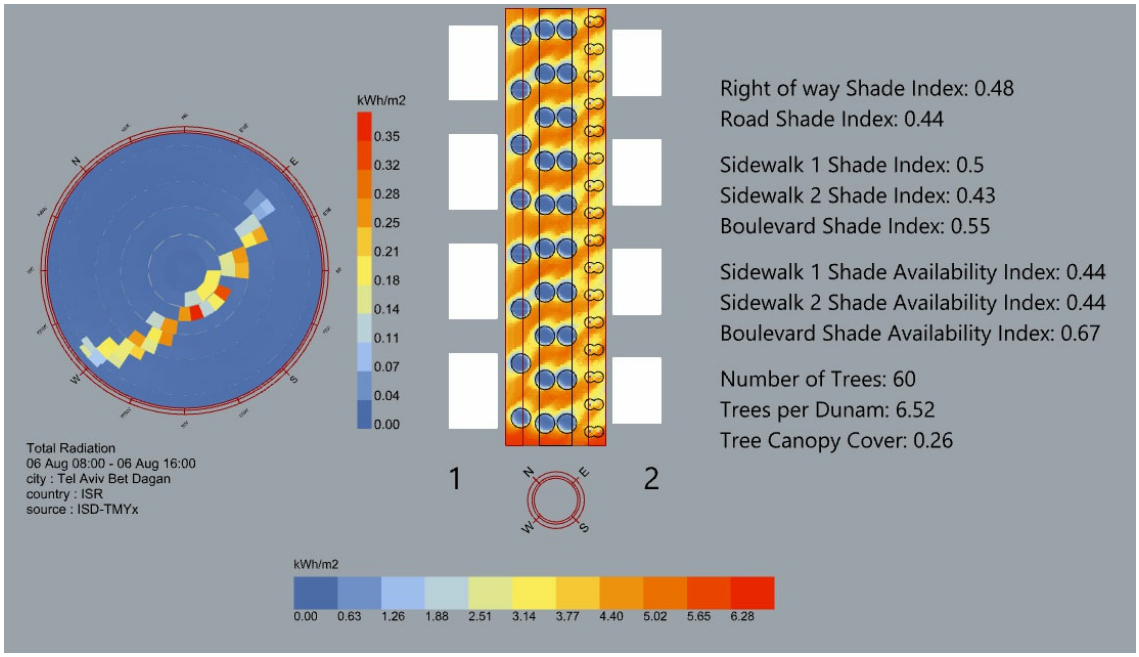
Abstract

To date, there is a lack of an orderly and data-based method for quantifying, evaluating, and benchmarking street-level outdoor shade in streets and urban public spaces. The lack of such a method impedes the design of streets where effective shading takes place at the most critical times. The purpose of the tool we developed as part of the "Israel 100" project was to provide planners and planning authorities with a relatively simple parametric tool that allows them to examine the impact of design alternatives on outdoor shade provision. The tool calculates several shade and tree indices, some we have developed in previous works, for each examined design, giving users quick and straightforward feedback and enabling them to quantitatively compare the shade assets of design alternatives.

The tool we developed is implemented as a Grasshopper code that allows users to design shading in streets by following an ordered sequence of actions: determining street orientation and dimensioning the street's right of way; determining the width of sidewalks, landscaping strips, auxiliary strips, and traffic lanes; determining building dimensions and density along the two sides of the street; and adding shading components of two types: trees of predetermined sizes and shapes and awnings protruding from building facades. Based on this geometry, the tool automatically computes the following values: a summer shade index for each sidewalk and the entire street; a shade availability index that indicates the period of time throughout the day when at least 50 percent of the sidewalk area was shaded; tree trunk density index per street; and street tree canopy cover. Beyond these quantitative metrics, the tool also provides visual feedback on ground-level shading, presenting the typical pattern of shade distribution across the street. This helps in interactively tweaking design based on the quantity and quality of shade provision.



Session Themes

Urban climate methods: Modelling

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How does urbanization affect tropical cyclone rainfall- Inference from observations and convection-permitting model experiments

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Abstract

How urbanization affects tropical cyclone (TC) rainfall is inferred from hourly station observations over the Great Bay Area (GBA) and numerical model experiments. Based on data for 41 TC cases from 2008 to 2017, TC extreme rainfall (99th percentile of hourly rainfall) tends to be stronger over urban compared to rural stations. During TC passages, surface wind at GBA urban locations is noticeably weaker; and the urban heat island (UHI) effect is highly suppressed ~10 hours before the peak of TC rainfall. Using the Weather Research and Forecasting (WRF) model coupled with an urban canopy module (UCM) and with ERA-Interim data as boundary conditions, dynamical downscaling was carried out for 8 selected TCs. Three parallel experiments were conducted for each storm: “Nourban” in which urban land use was replaced by cropland, “AH0” and “AH300” in which the anthropogenic heat (AH) diurnal maximum is set to zero and 300W/m2 in urban locations respectively. Hourly TC precipitation intensity and probability in all ranges (most obvious for hourly rainfall > 40mm) were increased significantly over the GBA megacity in both AH0 and AH300, especially for “slowly moving” TCs. This can be attributed to urban frictional effect, leading to enhanced low-level moisture flux convergence; on the other hand, the AH impact is weak. However, for 2 TCs (namely TC Mangkhut and TC Goni), extreme AH (thus the UHI effect) can still influence TC rainfall; in these special cases CAPE is rebuilt when TCs move away from the city area. Overall, urbanization can intensify extreme TC rainfall over the coastal GBA megacity mainly due to urban frictional effect, and we speculate that these effects tend to be stronger for slower storms.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

20

The impacts of shade on pedestrian behavior

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Abstract

This research examines the impacts of shade on city sidewalk users' behavior. While it is commonly assumed that such behavior is affected by harsh climatic conditions, and that outdoor heat stress reduces human presence in urban spaces, monitoring of real-life urban situations may reveal differences between expected and actual effects.

Our goal was to compile and analyze a large body of empirical evidence, demonstrating the extent to which shade influences the behavior of pedestrians and cyclists under summer daytime conditions. Using a digital camera to perform automated high-frequency photographic documentation, we monitored pedestrian and bicyclist activity in central Tel Aviv, Israel, in the summer of 2020. Photographic and microclimatic data were simultaneously collected at a series of 36 monitoring locations between 10:00-17:00, over the course of nine days. The images were used to manually count pedestrians and cyclists and to compare the number of people traveling in shaded vs unshaded spaces. Additionally, we examined the photographic evidence for specific behaviors which indicate people selecting shade.

We identified 5,323 people, 60% of whom travelled in the shade. At locations where the size and functionality of shaded and unshaded spaces were most comparable, 67% of all sidewalk users and 71% of all pedestrians travelled in the shade. When pedestrians were exposed to higher levels of radiation, due to the angle of incidence and intensity of solar radiation, the relative tendency of traveling in shade was found to increase systematically, at sites with over 100 pedestrians.

Ultimately, it appears that people are influenced by microclimatic conditions to the extent that under thermally stressful circumstances, they are likely to use better-shaded spaces. This study's extensive sample size increases our confidence in suggesting that, in hot climates, people are indeed more likely to use major sidewalks and public open spaces if they are well-shaded.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Impact of urban physics on simulation of thunderstorms

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Abstract

This study assesses the impact of urban Land Use Land Cover (LULC) on the evolution of mesoscale convective systems over Bhubaneswar, the first smart city in India. In the last two decades, the built-up area in the urban area has increased by about 77% at the cost of natural vegetation. It is well known that urban conditions influence severe convective events such as thunderstorms. Hence, the urban processes need to be incorporated for accurate simulations. In this study, we attempted to study the impact of urban physics in the simulation of severe thunderstorms. The high-resolution Weather Research and Forecasting (WRF) model is run at 2 km horizontal resolution with no-urban and single-layer urban canopy model. The Single-Layer Urban Canopy Model (SLUCM) leads to better rainfall intensity and movement of thunderstorms. The amount of rainfall is verified for different thresholds and urban physics is resulted in with least RMSE and absolute error. It also captured the surface variable before and after the storm life. The instability indices such as K Index (KI), Total totals Index (TTI), Convective Available Potential Energy (CAPE) and Lifted Index (LI) are also well represented in the urban canopy model. Thus, the study infers that urban surface physics is crucial in the prediction of thunderstorm events.

Session Themes

Urban climate methods: Modelling

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Mapping changes in tree, turfgrass, and senesced vegetation cover during a multi-year drought in Los Angeles, California

Dr. David L Miller ORCID iD[1,2], Dr. Erin B Wetherley ORCID iD[1], Dr. Dar A Roberts ORCID iD[1], Dr. Christina L Tague ORCID iD[1], Dr. Joseph P McFadden ORCID iD[1]

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Abstract

Trees and turfgrass lawns in urban areas can provide many ecosystem services, such as cooler temperatures. In water-limited climates, maintaining benefits from vegetation during droughts requires significant water inputs and can be challenging due to the uneven effects of drought on vegetation. Here, we tracked changes in vegetation cover in Los Angeles, California using airborne imaging spectrometer data acquired annually from 2013 to 2018 and coinciding with the exceptional 2012-2016 California drought. Subpixel fractional cover of trees, turfgrass, non-photosynthetic vegetation (NPV; e.g., senesced plant material), and non-vegetated urban surfaces were mapped at 18 m spatial resolution using Multiple Endmember Spectral Mixture Analysis. We quantified cover changes through time, comparing how different physiographic regions of the city experienced vegetation change and assessing changes based on income and outdoor water use. From 2013 to 2018, overall turfgrass cover decreased (-17%) and NPV cover increased (+22%). Tree cover was more stable but decreased in 2018 (-6%). The inland valleys consistently lost more turfgrass than coastal areas, indicating that different climatological regions in Los Angeles had distinct vegetation responses to drought. Higher income and water use areas had larger absolute changes in vegetation cover, likely due to their higher baseline of vegetation cover. Relative to their mean amount of existing vegetation cover, the lower-income and lower outdoor water use areas more often had the greatest tree cover changes, and turfgrass and NPV changes became more similar across all income and outdoor water use levels. Our results demonstrate how studies of urban vegetation cover changes and climate impacts can benefit from finer-scale spatial and vegetation type distinctions to gain a more detailed picture of local climate and drought impacts within urban landscapes.

Session Themes

Urban climate methods: Observations

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Bridging underpinning research capability and trans-disciplinary thinking for integrated urban service development in the UK

Dr Claire Scannell
UK Met Office, Exeter, United Kingdom

Abstract

Cities globally are coming under increasing pressure to mitigate, plan for and adapt to risks posed by climate change and its adverse impacts on urban society and city systems. Cities are complex multi-faceted systems with unique social norms and vulnerabilities to climate change and urban services need to deliver actionable information within this complex local context.

Understanding this local perspective scientifically is at the frontier of our technical and scientific capability and understanding. Merging this with the nuanced thinking required to understand the lived experience that drives behavioral change requires another step change in service development for cities but is critical to the robust development of integrated urban services at this local scale. Engaging and collaborating effectively across this interface enhancing the science to application process enables the identification of gaps and synergies between the underpinning capability and service development and user action. It enables the leveraging of emerging science for novel services and can provide demonstrable evidence for new or further research.

Within the UK the Met Office has been working closely with cities and research teams across the country to understand the requirements, capability and barriers for integrated urban service development from a scientific, service, social and decision relevant context. Here we provide examples of work developed within the UK illustrating the successful linkages between the science-service-user interface as well as first steps in embedding this within the social context of the city.

Session Themes

Integrated assessments of urban climate : Urban climate and climate change

24

Localized Heat Alert Response System using Smart Thermostats

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Abstract

An increase in smart home technologies has created an abundance of data that can be used for purposes beyond personal comfort and convenience. These Internet of Things (IoT technologies), like smart thermostats, can be used to support early warning and real-time heat health response guidelines and response systems.

As the climate warms, heat waves, once rare in Canada, are becoming more frequent, intense, and prolonged. Thresholds for responses are based on external environmental measures, whereas most deaths occur indoors. Smart thermostats can be a valid data source to guide timely response and policy during heatwave seasons.

We hypothesize that indoor temperatures may be different (i.e. higher) than outdoor temperatures used to develop policies and programs to mitigate and protect people during heatwaves. Our main objective is to develop a framework and recommendations for utilizing existing and deployed sensors to create a robust sensor network to inform public health messaging and policy. Data will be collected from 70 thermostats and participant surveys to provide insights on indoor temperatures and activities in Ottawa and Vancouver, Canada, from May to October 2022. We will share data with stakeholders via automated threshold-based email alerts and an interactive dashboard. We will compare inside temperatures with meteorological data from Environment Canada.

Developing robust localized heat health warning systems are essential to prevent heat-related illnesses, provide heat-relief programs, guide policy and municipal planning, and ultimately prevent deaths from extreme heat. We will share the findings of this study with local partners, BC Housing and Ottawa Community Housing, and public health organizations at all levels, including Ottawa Public Health, Vancouver Coastal Health, Fraser Health, BC CDC, Ontario Public Health, the Public Health Agency of Canada, and Health Canada.

Session Themes

Biometeorology & health: Urban environmental health

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Urban climate services to manage heat risks in cities

Victoria Ramsey, Dr. Claire Scannell
Met Office, Exeter, United Kingdom

Abstract

Local authorities globally are coming under increasing pressure to plan for and manage heat risks within their cities due to the increasing number of extreme heat events over the last number of years and their adverse impacts on urban inhabitants and city systems.

The UK Met Office has been working closely with several city councils and stakeholders both in the UK and China to understand the requirements for information on heat within cities to co-develop a prototype urban heat climate service to aid planning and decision making in urban areas. This poster will showcase the heat services that have been co-developed with cities in the UK and China.

City level factsheets called the “Heat Pack” provide tailored climate information on heat hazards for a specific city. The Heat Pack draws on the latest high resolution climate projections for the UK (UKCP Local) to provide information on future changes to impact relevant heat indicators for health, transport, energy and water sectors as well as changes to heatwave frequency, duration and magnitude. Several indicators have been mapped using ArcGIS which users have found extremely useful for understanding the spatial distribution of heat within the city. The Heat Packs aim to build depth in user understanding on heat hazards and associated impacts on their city.

A service to understand heat risk in cities has been developed with city stakeholders to identify where the most vulnerable people are located within the city. This takes the form of a heat vulnerability index which combines the climate projection information from the Heat Pack with other non-climate datasets to develop indicators of hazard exposure, sensitivity, and adaptive capacity to understand how risk changes under future climate through a set of heat risk maps. The results are communicated to users through an ArcGIS Storymap.

Session Themes

Integrated assessments of urban climate : Urban climate and climate change

26

Urbanization and the Evolving Heat Islands over the Indian Region

Soumya Satyakanta Sethi ORCID iD, V Vinoj ORCID iD
Indian Institute of Technology Bhubaneswar, Bhubaneswar, India

Abstract

The unprecedented growth of Indian cities, both in size and number of inhabitants, makes a large section of the people vulnerable to the ill impacts of urban-led local changes to the climate. Surface Urban heat island (SUHI) effect is one such signature due to changed urban land surface characteristics and enhanced anthropogenic warming. The current study assesses the SUHI over 141 major cities across India over the last 18 years (2003-2020). The SUHI climatology and its evolution pattern over these cities for both day and night time cases are explored. The study reveals strong positive nighttime and daytime SUHI with the exception of some cities showing a negative SUHI (approx 29% cities). A large disparity is found in diurnal SUHI intensity, with annual mean nighttime and daytime intensities being 1.15 ± 0.51 °C and 0.64 ± 1.29 ℃, respectively. Desert cities were observed to have the maximum diurnal deviation in magnitude. Significant intensification of average nighttime and daytime SUHI at a rate of 0.19 ± 0.14 and 0.24 ± 0.3 ℃/decade was observed. Cities in the Indo-Gangetic basin are found to show a consistent positive SUHI intensity and trend irrespective of the time throughout the year. We will further discuss the seasonality and trends of SUHI intensity and its changes in detail.

Session Themes

Urban climate methods: Observations

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W-UCP, a WUDAPT development of an open-source tool for deriving Urban Canopy Parameters to facilitate uWRF and other fit-for-purpose modeling applications

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Abstract

Following the increase in the usage and attention of the WUDAPT dataset for various urban fit-for-purpose modeling applications, we have created an open-source, unified methodology for the urban community to generate user-specified model inputs of gridded urban canopy parameters (UCPs) to facilitate the progress in worldwide urban climate modeling and information exchange. This poster presents the development of the W-UCP tool that derives gridded UCPs based on the commonly used vector-format 3D building dataset. This tool is developed based on a python script plugin in the open-source GIS software (QGIS), which is also user-friendly. This tool facilitates generating gridded UCPs for urban WRF model at different resolutions; it can also be useful for spatial analysis of UCPs in their cities and studying its relationship with different in-situ measured meteorological variables for UHI and other similar studies. Results are shown for the Hong Kong region, and the output is directly converted to the binary tile format that is ready to be used for driving the mesoscale meteorological model (WRF) as a demonstration for the worldwide research community, thus enhancing the evaluation of different fit-for-purpose modeling at different scales. The tool could be further expanded and customized for other fit-for-purpose modeling studies.

Session Themes

Special Session: World Urban Database and Access Portal Tools (WUDAPT): World Urban Database and Access Portal Tools (WUDAPT)

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Estimation of current and future human thermal comfort levels on very hot summer days in Lisbon

Mrs. Cláudia E. Reis ORCID iD[1], Dr. André S. Nouri ORCID iD[2], Dr. António S. Lopes[1]
[1]Institute of Geography and Spatial Planning, University of Lisbon, Lisbon, Portugal. [2]University of Bilkent, Ancara, Turkey

Abstract

Today, urban areas with Mediterranean climates offer a very discomfort thermal environment for citizens during summer. Due to the urban heat island (UHI) effect, they are hotter than their surroundings. This pattern will be aggravated by future climate projections of increasing air temperatures and more frequent and intense heat waves, with negative consequences on human health. In this investigation current and future thermal comfort conditions were modelled in 12 urban canyons located in Lisbon based on the Local Climate Zones (LCZ). For the meteorological input data, 163 very hot summer days between 2008 and 2014 (average maximum and minimum temperatures of 28ºC and 23ºC) were chosen considering the most frequent Local Weather Types in Lisbon. Physiologically Equivalent Temperature (PET), Universal Thermal Climate Index (UTCI) and Mean Radiant Temperature (MRT) were modelled in SkyHelios for two time periods (00:00h to 03:00h and 12:00h to 15:00h). In order to estimate future thermal comfort conditions, monthly anomalies for RCP's 4.5. and 8.5. and for the periods of 2041-2070 and 2071-2100 were added to current conditions of this LWT. Results showed that urban canyons with lower urban density present the highest thermal discomfort levels (LCZ's 4 to 6 with average diurnal PET, UTCI and MRT of 39,3ºC, 34,8ºC and 53,9ºC, respectively), while areas with dense tree cover had lower PET, UTCI and Tmrt (diurnal values of 31,2ºC, 31,7ºC and 44,5ºC, respectively). Future projections depict similar increases in thermal discomfort in all sample areas (RCP 4.5. 2041-2070 – average increase in PET, UTCI and MRT of 2ºC, 2,1ºC and 1,5ºC, respectively; RCP 4.5. 2071-2100 – 2,3ºC, 2,4ºC and 1,8ºC; RCP 8.5. 2041-2070 – 2,5ºC, 2,7ºC and 1,9ºC; RCP .8.5. 2071-2100 – 4,4ºC, 4,7ºC and 3,4ºC.

Session Themes

Biometeorology & health: Urban microclimate and comfort

29

Mitigation of Urban Thermal Environment by River

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Abstract

Rivers in cities can mitigate thermal environments on hot summer days. This paper presents a discussion of physical mechanisms of that mitigation using field measurements taken in downtown, Tokyo. We took two measurement sites; the shallower and the deeper river.

Figure 1 summarizes physical mechanism of thermal mitigation by river. Cold river water could cool down the urban air (Fig. 1a). In our measurement at the deeper river, water surface was colder than the air in daytime. Consequently, sensible heat was transferred from air to the water surface and air was cooled. However, the shallow river water had higher temperature and it heated air. This cooling/heating feature at deeper/shallower river took a 180-degree turn at nighttime; the deeper water cooled air and the shallower water heated air in nighttime. This turn between daytime and nighttime was attributable to the observed fact that most part of the net radiation at the water surface was partitioned into heat storage in daytime. Therefore, the adequate water depth for the urban thermal mitigation depends on the time of day.

Openness of river in a crowded urban canopy also brings us thermal mitigation (Fig. 1b and 1c). In our measurement, quadrant analysis of turbulent fluctuation revealed the downward motion of colder air above the river. The cold air mass above urban canopy intruded into the canopy through the open area above the river and cooled down the pedestrian-level air.

Session Themes

Urban climate processes: Boundary layer and urban canopy layer processes

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Transforming the City into a Garden: Simulating the cooling effects of vegetation in tropical Singapore on ENVI-met

Peter J Crank ORCID iD[1,2], Graces Ching ORCID iD[1], Yuliya Dzyuban ORCID iD[1,2], Shreya Banerjee ORCID iD[1,3], Sin Kang Yik ORCID iD[1], Rachel Pek Xin Yi ORCID iD[1], Winston TL Chow ORCID iD[1]
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Abstract

Cities experience excess heat due to urban heat island (UHI) effects and climate change, posing a threat to human health and well-being. To address this, microclimate modelling has the potential to inform urban planning and heat mitigation strategies to improve outdoor thermal comfort (OTC). In this study we used ENVI-met (v. 5.0.2), a 3-D numerical model to quantify the cooling benefits of tree planting efforts in the tropical hot-humid city of Singapore. The site of study is Bishan-Ang Mo Kio Park, a 62-hectare park surrounded by dense high-rise residential housing located in central Singapore. In-situ measurements of microclimatic variables using high-precision Vaisala weather instruments were taken at the area of study for validation of the model (driven by a weather station ~2 km away). Two simulations were run - a “concrete jungle” scenario without any green space and a current conditions scenario with trees and grass planted as the park is today. Model validation using the index of agreement (d) of ENVI-met to in situ air temperature measurements were good (d=0.88), but relative humidity validation was better (d=0.98). Park design results showed cooling of up to 1°C due to shading provided by trees under the vegetated scenario compared with the concrete jungle scenario. Thus, tree planting efforts are shown to be mostly effective in reducing urban temperatures in the immediate area. This is particularly noticeable during peak park usage hours (6am-10am & 4pm-8pm). However, low wind conditions in Singapore minimise the advection of these cooling impacts. Overall, this present study highlights how numerical modelling tools are a valuable resource for researchers and policymakers to evaluate mitigation strategies, but an understanding of the limits of the model and the need for validation is essential to verify the reliability of the model’s results for future application.

Session Themes

Urban climate methods: Modelling

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How do urban carbon dioxide emissions, urban scale and population density relate to each other? A literature based discovery

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Abstract

Carbon dioxide (CO2) emission is considered as a highly relevant metric for urban climate change mitigation. Urban areas are attributed to more than 70% of such emissions although they cover only around 0.4-0.9% of global land area. Therefore researchers across several disciplines have been investigating upon the effects of urbanization on CO2 emissions by proposing various emission accounting methods in the city level, such as, socio-economic activities in geographical boundaries based, consumption activity based or community infrastructure based emission accounting methods.

Our current study employs a literature based discovery method to identify relationships between urban population density and CO2 emission efficiency for urban areas. We analyze and assess the various emission accounting methods for applicability in such correlation studies between city size, population density and emissions. We also study the various statistical and econometric models that correlate emissions with urban density, such as the Power Law, Urban Kaya Scaling, and Production Function based models. We discuss the strengths and weaknesses of these models. We raise two pertinent research questions- first, how urban population size relates to CO2 emissions for various city sizes- is there a pattern inherent? Second, how does population density affect CO2 emission per capita in city level? Our study also attempts to identify the value of CO2 emissions that can be attributed to various land-use types in urban areas and in various contexts.

As urban areas around the world are looking for carbon neutrality, the findings of this study would be potentially insightful in aligning the development trajectory of sustainable urbanization with economies of scale in CO2 emission of urban areas.

Session Themes

Urban climate policy: Planning and Governance

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Mental Health and Air Temperature: Attributable Risk Analysis for Schizophrenia Hospital Admissions in Arid Urban Climates

Dr Peter J Crank ORCID iD[1], Dr David M Hondula ORCID iD[2], Dr David J Sailor ORCID iD[2]
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Abstract

Health researchers have examined the physiological impacts of extreme heat on the human body. Yet, the mental health impacts of temperature have been understudied. Research has shown that the environment can create circumstances that exacerbate mental health issues. This may be a particular challenge for some of the fastest growing cities, located in hot, dry climates. Given the theoretical relationship between heat and mental health, we seek to measure the association of temperature and schizophrenia hospital admissions in an arid urban climate and quantify the associated public health burden. We collected 86,672 hospitalization records for schizophrenia from 2006-2014 in Maricopa County, Arizona, USA. Using a distributed lag non-linear model (DLNM), we tested for a statistical association between temperature and schizophrenia hospital admissions after controlling for year, season, weekends, and holidays. We calculated the cumulative attributable risk of nighttime temperature on schizophrenia for the entire dataset as well as among demographic subgroups. The relative risk of schizophrenia hospital admissions increased with both high and low temperatures. Statistical models using daily minimum temperature were more strongly associated with hospitalization than those using daily mean or maximum. Schizophrenia hospital admissions increased on days with minimum temperatures above 30 °C, with some subgroups experiencing higher rates of hospitalization. The total fraction of schizophrenia hospital admissions attributable to non-optimal ambient minimum temperature is 3.45% (CI: -4.91-10.80%) and high ambient minimum temperature is 0.28% (CI: -1.18-1.78%). We found that non-whites and males appear to be at a slightly increased risk than the general population, although there did not appear to be a statistically significant difference. A conservative estimate of subsequent healthcare costs annually from non-optimal temperature attributed schizophrenia hospitalization is $1.95 million USD. Therefore, focusing on nighttime cooling strategies and efforts to increase the accessibility of shelter to reduce overnight exposure to high and low temperatures.

Session Themes

Biometeorology & health: Urban environmental health

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Urban Growth and Climate Risk in the Mexico City Metropolitan Area

Mrs Nuria D Vargas, Dr. Victor Magana
UNAM, Mexico City, Mexico

Abstract

The climate of large cities changes as urbanization grows, generating Urban Heat Islands. In recent decades, the growth of Mexico City and its metropolitan area has been characterized by the deforestation of large areas of natural vegetation, in relation to poorly planned urbanization which results in significant changes in climate that manifests as increases in maximum temperature of the order of 3-4 ºC in the last 100 years and with changes in the precipitation regime, with increases of up to 40% in a century, mainly due to the more intense rain events.

As land use changes, processes are generated that make the population vulnerable to extreme weather events, such as heat waves and extreme rains. The loss of vegetation as a main component in the analysis of vulnerability to climate change in Mexico City and its metropolitan area, allows estimating the importance of having ecosystem services to maintain a certain degree of well-being in the population. The thermal and hydrologic regulation provided by the vegetation has been lost which results in more frequent levels of critical risk of negative climatic impacts among the population.

In short, in the ZMVM meteorological hazards related to heat waves and intense rains have increased and so the negative impacts. Acute diarrheal diseases among in children under 14 years of age after episodes of hot weather, or intense rains and urban floods and landslides are examples of higher risk due to the lack of urban planning, that is materializing not only in more material losses but
even human lives.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

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Study on building energy estimation using UAV equipped with an infrared camera

Assistant Professor Yukiko Yoshida[1], Chief Senior Researcher Toshiaki Ichinose[2], Chief Senior Researcher Yujiro Hirano[2]
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Abstract

In this study, comparing the building surface temperature values measured by indoor and outdoor thermal cameras, based on the building outside skin area and azimuth coefficient. By calculating the radiation amount and comparing it with the window surface temperature, room temperature measurement, and average radiation temperature value of the perimeter zone, on validated the building energy estimation method using the UAV equipped with a thermo camera would be examined.
The flight experiment of the UAV equipped with a thermo camera is scheduled on the campus of the Faculty of Engineering, Ibaraki University, and it is in an environment where data such as the actual power consumption. Therefore, the data necessary for meteorological observation, data acquisition regarding window load, and discrimination of other complex elements are available in an environment where they can be acquired. Outdoor exposure measurement by comparing window performance is performed on the premises of the Faculty of Engineering, Ibaraki University, where the shadow of the adjacent building does not occur because it is not in the city center.
Due to COVID-19, the occupancy rate of each building varies from day by day, and it is difficult to know in detail, so the need for information technology such as smartening is increasing.

Session Themes

Climate-conscious design and sustainable development : Building climates and energy

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Improvement and verification of urban extreme temperature predictions with satellite and ground observations in Austria (VERITAS-AT)

Dr. Sandro Michael Oswald ORCID iD, Dr. Stefan Schneider, Dr. Claudia Hahn, Dr. Maja Zuvela-Aloise, Dr. Clemens Wastl
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Abstract

Extreme temperatures, especially long-lasting heat and cold waves in urban areas, lead to thermal stress of the population and increase the number of weather-related health risks and deaths. The observed climate trend and the associated increase of extreme weather events are expected to continue in the future. Thus, the evaluation of urban thermal stress and the associated health effects becomes an important issue for urban planning and risk management. For Austrian cities, an information system for temperature warnings already exists (ZAMG), which is based on the information of regional weather forecast models. However, this information does not have the required spatial resolution needed to resolve urban structure and thus to account for the urban heat island effect.

Therefore, the aim of this project is to provide the basis for the improvement of extreme weather/thermal (dis)comfort warning systems in Austrian cities by using high-resolution weather predictions. Furthermore, the results will be verified with satellite and in-situ (crowd-sourced) observations. The soil model SURFEX (Météo France) coupled with the AROME numerical weather forecast model, is applied to selected cities in Austria and used to determine the best model configuration to compute short-term forecasts (+60 hours).

In the project, land use parameterization will be updated and improved based on Pan-European High Resolution Layers (e.g. Urban Atlas) of the Copernicus Land Monitoring service in ECOCLIMAP (predefined land use classes for SURFEX). The model output will be compared to the micro-scale urban climate model MUKLIMO_3 from the German Weather Service (100 m) and various thermal infrared (TIR) datasets. The novel modeling approach for simulating thermal stress in urban areas serves as the basis for improving the operational prediction of extreme temperatures, for optimizing the future extreme weather warning system at the ZAMG, and for decision-making for the involved cities and their stakeholders.

Session Themes

Urban climate methods: Modelling

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A Quantification of Classic But Unquantified Positive Feedback Effects in the Urban-building-energy-climate System

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Abstract

The interaction between urban air temperature (T) and building cooling energy demand (E) generates a well-known positive feedback (PFB), which is mediated by sensible anthropogenic heat (Q_{fS}) and named Q_{fS}-T-E PFB in this study. This PFB could induce self-reinforced warming, but its effects have not been completely quantified. Hence, this study aimed to clarify these effects by targeting Osaka, a Japanese major city. Focusing on the from-weekends-to-weekdays increase in urban energy consumption including E increase as an observable trigger of the PFB, its induced T rise due to growth in Q_{fS} was estimated with the fed-back additional E gain on weekdays based on observed ground-level T and district-wise electric power consumption during summer. The result indicated that the weekdays–weekends contrast in energy consumption over Osaka could induce the Q_{fS}-T-E PFB effects, which resulted in fed-back E gain reaching 10% on weekdays. Such observational PFB impact on E was found to be reproducible by the proposed urban meteorological model, named WRF-CM-BEM. Thus, the validated model was applied to the quantification of the PFB impact on T based on feedback gain (g_A) which means a percentage of T variation caused by the PFB. An attempt was made to quantify g_A through the two-cases simulations of the weekdays-run and holidays-run for the months of August in 10 years. The simulations provided estimates on g_A, whose daytime averages reached nearly 10% in the downtown commercial areas and 20% in the leeward-located residential areas, suggesting the influence of sea breeze heat advection of downtown Q_{fS}. Such estimated impacts on T were roughly in the same order of magnitude compared to those in a few earlier studies that were not based on observational validations and seemed to be non-negligible, considering the feedback impacts on global surface warming estimated with g_A of approximately 50% by IPCC.

Session Themes

Integrated assessments of urban climate : Inter-scale interaction of urban phenomena and climate

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Modelling long-term trends in spatially distributed mean radiant temperature in a complex urban environment using a convolutional encoder-decoder network

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Abstract

We present the applicability of a novel method for modelling long-term mean radiant temperature (T_{mrt}) with high spatial and temporal resolution in complex urban areas. We modelled hourly T_{mrt} for two 30-year periods (1961 – 1990, 1991 – 2020) on two 500x500 m areas at 1 m spatial resolution at 1.1 m a.g.l. One area is a subset of the city centre of Freiburg (Germany), while the second area is located outside the city centre and consists of mainly meadows. Both domains are driven by the same hourly ERA5 reanalysis data.

The proposed model is based on a convolutional encoder-decoder network (U-Net). The response data of the U-Net training procedure comes from the urban micro-scale model SOLWEIG. Spatial and temporal predictors of the U-Net are the same as the input data of SOLWEIG. Model accuracy of the U-Net model is high, with a mean absolute error of 2.4 K. Furthermore, the U-Net is 30 – 130 times faster than SOLWEIG.

The results of the U-Net application show that summertime average daily maximum T_{mrt} increased by 2.6 K for the city centre and by 2.2 K for the meadow area from 1961 – 1990 to 1991 – 2020. Average daily maximum T_a, however, increased only by 1.5 K during the same period. The number of hours per year and pixel with $T_{mrt} \geq 60$ °C increased by an average of 8 additional hours from period one to period two, with the highest increase to the south of buildings. Furthermore, maximum T_{mrt} increase varies between different land cover types with 1.7 K increase for grassy tree covered pixels and 2.9 K for non-tree covered paved pixels in the city centre.

In summary, the proposed U-Net approach is able to emulate a micrometeorological physical model with computational superiority, enabling spatially differentiated, long-term climate change detection in complex urban environments.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Future climate projection of heat indices for Austrian major cities: developing Climate Services to improve climate resilience in urban areas

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Abstract

Climate indices for heat conditions in urban regions can support sustainable urban planning, risk management and environmental protection. In the scope of the e-shape project and the EuroGEO initiative, a number of pilot applications have been developed to support user-oriented services based on Earth Observation data. The showcase "Urban resilience to extreme weather" develops climate services for urban regions and, among others, derives climate change projections on urban scale including spatial heat condition variations related to the Urban Heat Island effect.

In this pilot application, heat indicators for selected urban regions in Austria were calculated based on dynamical urban climate model and regional climate model projections. In order to describe land surface properties, national and EU data sets were used as input such as products of respective Copernicus services (e.g. Urban Atlas and Tree Cover Density). The results provide spatial high-resolution maps (~100 m) and time series of climate indices related to heat conditions for past and future climate under different climate scenarios. As driving factors, the regional climate model simulations from the EURO-CORDEX project for the time period 2011-2100 were used as well as an ensemble of eight different combinations of bias corrected regional/global climate model outputs under climate change scenarios RCP4.5 and RCP8.5 was evaluated.

The aim of the pilot is not only to provide the climate information, but also to improve the data uptake by end users through standardising modelling methodology, as well as formats, and facilitating data access. For this reason, the data are prepared in INSPIRE conform NetCDF format and are available through the Austrian national Climate Change Data Centre. The existing data services enables quick visualisation in displaying the spatio-temporal evolution of climate indices on an interactive map and selection of time series for specific locations, which facilitates data analysis and interpretation.

Session Themes

Special Session: High-resolution future climate projections for cities: The state-of-the-art and undelaying challenges

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Shady Results: The Impact of Solar Radiation Shields on Measuring Urban Heat Parameters in Sultry Climates

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Abstract

The Urban Heat Island (UHI) effect is a phenomenon that plagues many modern cities around the world today. Coupled with the impacts of climate change, anthropogenic heat (AH) emissions have greatly increased urban temperature, consequently impacting outdoor thermal comfort (OTC) of residents. Existing research on this phenomenon include measuring the changes in climatic variables, and the employment of various heat mitigation strategies to alleviate the adverse impacts on OTC. However, such research in the tropics with extremely humid and strong solar radiative conditions remain minimal. Thus, this study deployed 18 MX2301A Honest Observer by Onset (HOBO) Temperature/RH Data Loggers around an urban park in the hot humid tropical city of Singapore, and observed the differences in its responses to a setup with and without a RS1 Solar Radiation Shield. The experiment was conducted over two periods: (a) September 2021 to December 2021 without radiation shields, and (b) January 2022 to May 2022 with radiation shields. Ten MX2301A sensors were set up inside a public park, and eight more were set up in the surrounding urban high-rise area. Spatiotemporal analysis of the study area were then conducted using ArcGIS Pro, revealing a clear Park Cool Island (PCI) effect, with lower air temperature (Ta) observed within the park compared to the surrounding urban areas. The dataset with the radiation shields also recorded lower ranges of Ta and relative humidity (lower maximums and higher minimums), as well as overall lower dew point temperature. Ultimately, these results aim to reveal the extent of the PCI in tropical cities, and how effective parks and greenspaces are in reducing urban temperature. The study will also inform the effectiveness of using these measurement apparatus to observe micro-climatic variables, while also complimenting the lacking literature on UHI and heat mitigation in tropical environments.

Session Themes

Urban climate methods: Observations

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Impact of an enhanced green infrastructure on the urban heat island intensity

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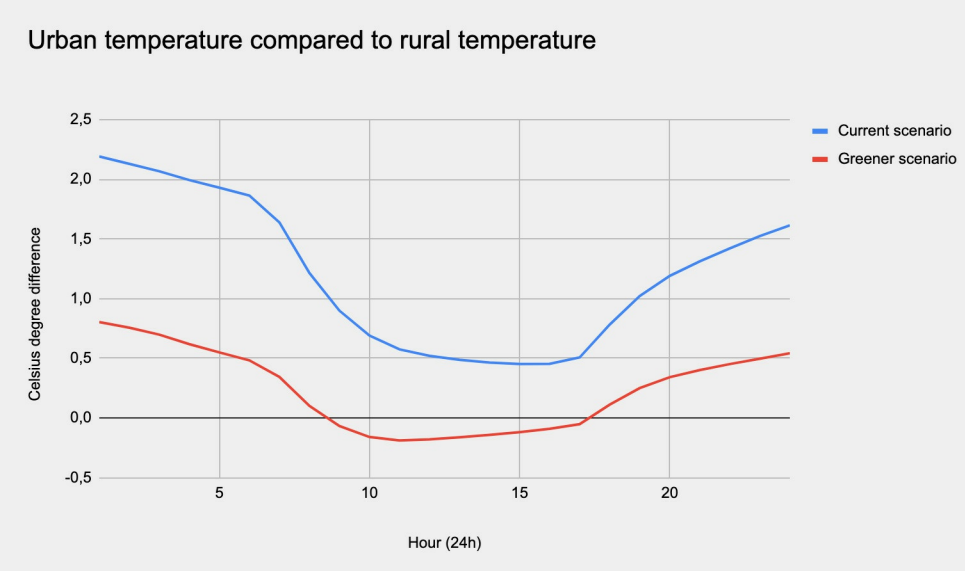
Abstract

Ten percent of Brazil's population is located in the Metropolitan Region of Sao Paulo (MRSP) area, composed of 39 municipalities and one of the most populated areas in the world. A booming build verticalization phase is happening to house all these citizens and the upcoming ones. Consequently, increasing the building density may change the urban climate, causing higher air temperatures. Alternatively, enhancing green infrastructure has been suggested as an urban heat island mitigation strategy. Nonetheless, it is unclear how efficient an increase in green infrastructure decreases urban heat island intensity (UHII). Therefore, an updated numerical analysis is still missing and it is relevant to public policies aiming to cool urban air and promote healthier lives for the MRSP area's citizens. This study aims to determine the impact of an enhanced green infrastructure on the UHII of a large metropolitan area. We used the Weather Research and Forecasting (WRF) meteorological model to simulate a sunny winter day in two different scenarios: one used the current land use pattern and the local climate zones (LCZ) urban classification; the other simulated a greener MRSP, in which less vegetated LCZ urban classes were changed to more vegetated ones. We calculated the UHII as the difference between the average urban air temperature (considering all urban classes) and the average rural air temperature (considering all non-urban classes). A substantial air temperature drop occurs by increasing the green infrastructure. The simulation also shows that air temperature fluctuates less in the greener scenario (0.98oC versus 1.74oC). Moreover, variations seem to be less abrupt in the greener scenario, as shown in data around the 7 and 17 hours. We conclude that in a large metropolitan area, such as the MRSP, an enhanced green infrastructure can decrease the city's air temperature and help mitigate UHII.



Session Themes

Urban climate processes: Boundary layer and urban canopy layer processes

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Analysis of urban surface heat balance using satellite remote sensing data

Chief Senior Researcher Yujiro Hirano[1], Chief Senior Researcher Toshiaki Ichinose[1], Assistant Professor Yukiko Yoshida[2], Professor Yohei Shiraki[3], Professor Akio Onishi[4]
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Abstract

The purpose of this study is to analyze the surface heat balance of urban areas by using satellite remote sensing to acquire parameters for simulating the surface heat balance of urban areas. Previous studies have used mesoscale meteorological models to simulate urban climates. In such cases, since detailed urban land covers and geometric shapes cannot be represented by mesoscale models, it was common to set the physical characteristics of the ground surface using land use data. However, the land use data are not necessarily in agreement with actual land-cover, and thus, the calculation result depends on the parameter settings. Therefore, we developed a one-dimensional heat balance model and proposed a method to acquire parameters by physical calculation instead of empirical formula by connecting this model with satellite-observed ground surface temperature. As a result of simulating an actual urban area using this method, the effect of heat storage in the urban area, which was difficult to simulate with the conventional one-dimensional heat balance model, was well reproduced.

Session Themes

Urban climate methods: Modelling

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Investigating the impact of meso- and local-scale atmospheric circulations on urban climate and thermal bioclimate in a dense-populated, coastal Mediterranean city

Dr Christos Giannaros ORCID iD[1], Dr Ilias Agathangelidis[2], Dr Georgios Papavasileiou ORCID iD[1], Dr Elissavet Galanaki[1], Dr Vassiliki Kotroni ORCID iD[1], Dr Konstantinos Lagouvardos[1], Dr Theodore M. Giannaros ORCID iD[1], Dr Constantinos Cartalis[2], Dr Andreas Matzarakis ORCID iD[3,4]
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Abstract

Greece, which is situated in the eastern Mediterranean basin, is characterized by significant increasing trends in hot extremes and heat stress. Urban dwellers are especially at heat-related risk due to the excess warmth introduced in cities by manmade local climate changes associated with urbanization. However, not every citizen living in a given urban area is equally exposed to increased thermal discomfort. The development of effective strategies to mitigate the impacts of urban heat requires analyzing the effects of background weather conditions and atmospheric circulations on the urban thermal bioclimate. Addressing this need in the frame of the ADAPT2CC research project, a multi-scale modeling framework was employed to thoroughly investigate the meteorological and human thermal comfort conditions in the Athens urban area (AUA), Greece, before, during and after an extreme nine-day (July 25-August 08, 2021) heat wave (HW) episode that affected the area. The results highlight the great heat stress burden – expressed by the modified physiologically equivalent temperature (mPET) – that put on the AUA population during the HW period and especially at night. Under both non-HW and HW conditions, the meso-scale northerly flow of Etesians led to lower daytime mPET values in the central and north AUA sectors compared to the south AUA region. On the other hand, the local-scale circulation induced by sea breeze cooled down the southern areas of AUA during the day by 1 – 3 ^{O}C. However, this cooling effect was not effective to also result in a more comfortable human thermal perception under the HW conditions. This outcome indicates that heat stress mitigation efforts in the southern AUA can focus on increasing the cooling effectiveness of sea breeze through ventilation corridors.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Where citizen science meets the urban environment: The Schools Weather and Air Quality (SWAQ) network

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Abstract

Sydney's population is predicted to grow by 30% within twenty years, most of which is slated for the semi-rural fringes. The resulting urbanisation may adversely impact temperature and air quality in these areas of rapid population growth. Both temperature and air quality can vary greatly within cities themselves due to spatial variability in land-use, surface characteristics, pollutant emissions, transport infrastructure and the geography of the city. Therefore, it is imperative to have high density meteorological and air quality observations across a city. This presentation will discuss the development of a citizen science project, SWAQ (schools weather and air quality), that has placed meteorology and air quality sensors in schools across Sydney. The sites complement existing networks in order to target regions lacking monitoring sites e.g., urban growth areas on the rural fringe. Students analyse this research quality data in science and maths curriculum-aligned classroom activities. The data collected is published and available freely available online to researchers.

Session Themes

Urban climate methods: Observations

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Clothing color effect as a target of the smallest scale climate change adaptation

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Abstract

The effects of reflectance of solar radiation have been well studied in terms of the paints used on paving and on building surfaces. However, there is insufficient information on reflectance in terms of clothing color, which is important for outdoor thermal comfort. Color choice of the clothing in the outdoor space is regarded as one of important climate change adaptation strategies, in the viewpoint of the risk prevention of summer heat stroke. Since 2011, the authors have observed surface temperatures of polo shirts of the same material and design but different colors; the shirts were hung in unshaded outdoor open space (e.g. Lin and Ichinose, 2014). The reflectivity of the visible bands (the brightness) was one of the dominant factors which decide the surface temperature of the clothes. But survey on the effect of the near infrared bands (0.75-1.4μm), which share not a few parts of the solar radiation, was insufficient.

The maximum difference between green (higher) and red (lower) was almost 5 - 10 °C and was greatest when the solar radiation was strong. We analyzed spectrum of reflectance (0.35-1.05μm) on the surface of clothes. The reflectivity of each color in considering the near infrared bands as well as the visible bands was like as dark green 87%, black 86%, blue 84%, green 84%, purple 82%, red 78%, grey 75%, yellow 70% and white 63%. The difference of 25% in the reflectivity brings about 15 ℃ of temperature difference.

Lin, Y., T. Ichinose : (2014) Outdoor experiment investigation on the effect of clothing color to surface temperature variation. Third International Conference on Countermeasures to Urban Heat Island, Proceedings, 280-291

Session Themes

Biometeorology & health: Methods, applications, and translational research

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A global map of Local Climate Zones to support earth system modelling and urban scale environmental science

Dr. Matthias Demuzere ORCID iD[1], Jonas Kittner ORCID iD[1], Dr. Alberto Martilli[2], Dr. Gerald Mills ORCID iD[3], Christian Moede[1], Dr. Iain D Stewart[4], Dr. Jasper van Vliet[5], Dr. Benjamin Bechtel ORCID iD[1]
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Abstract

There is a scientific consensus on the need for spatially detailed information on urban landscapes at a global scale. This data can support a range of environmental services, as cities are acknowledged as places of intense resource consumption and waste generation and foci of population and infrastructure that are exposed to multiple hazards of natural and anthropogenic origin. In the face of climate change, urban data is also required to explore future urbanisation pathways and urban design strategies, in order to lock in long-term resilience and sustainability, protecting cities from future decisions that could undermine their adaptability. To serve this purpose, we present a 100 m resolution global map of Local Climate Zones (LCZs), an universal urban typology that can distinguish urban areas on a holistic basis, accounting for the typical combination of micro-scale land-covers and associated physical properties. The global LCZ map, composed of 10 built and 7 natural land cover types, is generated by feeding an unprecedented amount of labelled training areas and earth observation imagery into lightweight random forest models. Its quality is assessed using a bootstrap cross validation alongside a thematic benchmark for 150 selected functional urban areas using independent global and open-source data on surface cover, surface imperviousness, building height, and anthropogenic heat. As each LCZ type is associated with generic numerical descriptions of key urban canopy parameters that regulate atmospheric responses to urbanisation, the availability of this globally consistent and climate-relevant urban description is an important prerequisite for supporting model development and creating evidence-based climate-sensitive urban planning policies.

Session Themes

Special Session: World Urban Database and Access Portal Tools (WUDAPT): World Urban Database and Access Portal Tools (WUDAPT)

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Analysis of urban hot spots and nocturnal ventilation in hilly terrain

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Abstract

Due to global warming the conservation or enhancement of urban ventilation during calm and hot weather conditions receives increasing attention in spatial planning. Particularly, the transport of cool air from rural surroundings into the city by local winds during nighttime is important for the limitation or alleviation of the urban heat island intensity. A simple statistical method to objectively identify thermal hot spots and areas of rural cold air formation from urban climate model simulations is described and applied to Aschaffenburg, a medium-sized town located in hilly terrain in southwestern Germany.
The delimitated hot spots and nocturnal cold air formation areas are influenced by local land cover, but also by surrounding landscape heterogeneity, surface energy exchange and atmospheric mixing processes. The results therefore illustrate limitations of delimitation methods purely based on the analysis of classified land cover data. Nocturnal backward airflow trajectories from thermal hot spots in the city and forward trajectories from rural areas with substantial cold air formation are calculated to determine which cold air formation areas are actually contributing to ventilation and advective cooling of thermal hot spots or specific urban quartiers.
The described method provides guidance to urban and regional planners to protect important cold air formation areas from urban sprawl and it can be applied to study impacts of planning scenarios. Options for improvement or extension of the method are discussed.

Session Themes

Urban climate methods: Modelling

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An analysis of spatial-temporal variation in indoor air quality based on field measurements of an apartment

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Abstract

Air pollution is one of the biggest environmental challenges faced worldwide. Although it is mostly thought of as a concern outdoors, studies suggest indoor air can be polluted as well. India homes many of the most polluted cities yet has a large amount of naturally ventilated dwellings that are highly vulnerable to air pollution and poor health. Pollutant dispersion in the urban canopy layer of cities plays a vital role in determining the indoor air quality of a building. This study focuses on the analysis of the spatial-temporal distribution of air pollutants in and around a naturally ventilated apartment in winter and summer through on-site auditing. The apartment building is located in Kolkata, the capital city of West Bengal, and one of the six most polluted mega-cities in India. The indoor air quality audit was conducted in winter 2021 and summer 2022 and measured the following parameters: Temperature (0C), Relative Humidity (%), Air Velocity (m/s), PM2.5 (µg/m3), PM10 (µg/m3), TVOC (mg/m³), HCHO (mg/m³), C6H6 (mg/m³). The sampling points were indoors, immediate outdoor environment or window level, and at an outdoor ground level. A comparison of rooms based on fenestration factors like an openable window to floor area ratio, windward or leeward side openings, and natural ventilation type in the room: single side or cross-ventilation was carried out. The study findings put forward that the volatile organic compounds fall under the acceptable range as per the WHO indoor air quality guidelines in both summer and winter periods. Contrastingly, the particulate matter concentrations were alarmingly high in winter, sometimes higher indoors than outdoors. Based on these, this research attempts to demonstrate the causal relationship between air quality and the ambient mechanisms that impact the indoor environment.

Session Themes

Urban climate processes: Urban air quality

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Combining High-Resolution Land Use Data With Crowdsourced Air Temperature for Microclimate Analyses

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Abstract

The spatial variability of land cover in cities results in a heterogeneous urban microclimate, often not represented by regulatory meteorological sensor networks. Crowdsourced sensor networks have the potential to address this shortcoming with real-time, fine-grained temperature measurements across cities. We use crowdsourced data from over 500 citizen weather stations during summer in Sydney, Australia, combined with 100m land use and Local Climate Zone (LCZ) maps to explore intra-urban variabilities in air temperature. The crowdsourced data consists of 2.3 million data points that were quality controlled and compared with reference data from five synoptic weather stations. Sydney presents unique drivers for spatio-temporal variability, with its climate influenced by the ocean, mountainous topography, and diverse urban land use. We explore the interplay of geography with urban form and fabric on spatial temperature variability. Crowdsourced stations measured higher night-time temperatures, higher maximum temperatures on warm days, and cooler maximum temperatures on cool days compared to the reference stations. These differences are due to siting, with crowdsourced stations closer to anthropogenic heat emissions, urban materials with high thermal inertia, and in areas of reduced sky view factor. Distance from the coast was found to be the dominant factor impacting the spatial variability in urban temperatures, with diurnal temperature range greater for sensors located inland. Differences in urban temperature could be explained by spatial variability in urban land-use and land-cover. Temperature varied both within and between LCZs across the city. Crowdsourced nocturnal temperatures were particularly sensitive to surrounding land cover, with lower temperatures in regions with higher vegetation cover, and higher temperatures in regions with more impervious surfaces. Crowdsourced stations provide highly relevant data for health monitoring and urban planning, however, there are challenges including a lack of metadata and an uneven distribution of stations with a possible socio-economic bias.

Session Themes

Urban climate methods: Urban climate informatics

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Sentiment Analysis of Weather-Related Tweets from Cities within Hot Climates

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Abstract

Evidence exists that exposure to weather hazards, particularly in cities subject to heat island and climate change impacts, strongly affects individuals' physical and mental health. Personal exposure and sentiment to warm conditions can currently be expressed on social media, and recent research noted that the geotagged, timestamped and accessible social media databases can potentially be indicative of the public mood and health for a region. This study attempts to understand the relationships between weather and social media sentiments via Twitter and weather data from 2012 to 2019 for two cities in hot climates, Singapore, and Phoenix, Arizona. We first detected weather-related tweets, and subsequently extracted keywords describing weather sensations. Furthermore, we analysed frequencies of most used words describing weather sensations and created graphs of commonly occurring bigrams to understand connections between them. We further explored the annual trends between keywords describing heat and heat-related thermal discomfort and temperature profiles for two cities. Results showed significant relationships between frequency of heat-related tweets and temperature. For Twitter users exposed to no strong temperature seasonality, we noticed an overall negative cluster around hot sensations. Seasonal variability was more apparent in Phoenix, with more positive weather-related sentiments during the cooler months. This demonstrates the viability of Twitter data as a rapid indicator for periods of higher heat experienced by public and greater negative sentiment towards the weather, and its potential for effective tracking of real-time urban heat stress.

Session Themes

Urban climate methods: Urban climate informatics

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Similarities and dissimilarities between flow over realistic urban layouts and idealized building arrays

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Abstract

Modeling urban canopy flow relies on collecting flow properties over different urban geometry configuration. Conventionally, CFD simulations of urban flow are conducted over idealized building arrays arranged in aligned or staggered form with varying density to represent different urban layout in the realistic urban configuration. However, the urban surface is a highly heterogeneous system with diverse building shapes and streets, where the corresponding behavior of flow over it can be significantly different from idealized building arrays. In this study, similarities and dissimilarities of flow over idealized and realistic urban geometries are comprehensively evaluated by conducting Large-eddy Simulations (LES) over 120 urban geometries. The horizontal heterogeneity is addressed through comparison between realistic and idealized urban geometry with the same uniform building height. Over sparse configurations, flow over realistic urban geometry behaves similar with staggered building arrays, which is consistent with the conventional approach to calibrate urban canopy models. Nonetheless, realistic flow is found less responsive to the increased urban density, featured with higher wind speed and turbulence level, and lower turbulent momentum flux (TMF) compares to staggered layouts. Although such tendency resembles aligned layouts, where penetrating streets are kept across all densities that support jet-like flow, the inherent heterogeneity is responsible for the realistic urban layout. The distinction is perceivable from the contribution of dispersive momentum flux to the total momentum flux (DMF/(DMF+TMF)), where the proportion is monotonically increase (up to 50% of the total) with realistic denser layout, whereas such trend cannot be captured by idealized building arrays. To quantitatively depict the tendency of a realistic urban layout to behaves similar to the aligned configuration, a novel geometric parameter “alignedness” is derived by capturing the longest uninterrupted street in the dominant wind direction. Results show alignedness has a superior performance in reflecting flow penetrating into the urban canopy.

Session Themes

Urban climate methods: Modelling

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Potential of Synthetizing Climatopes and Local Climate Zones for Urban Climatic Planning Recommendations: A Case Study in Toulouse, France

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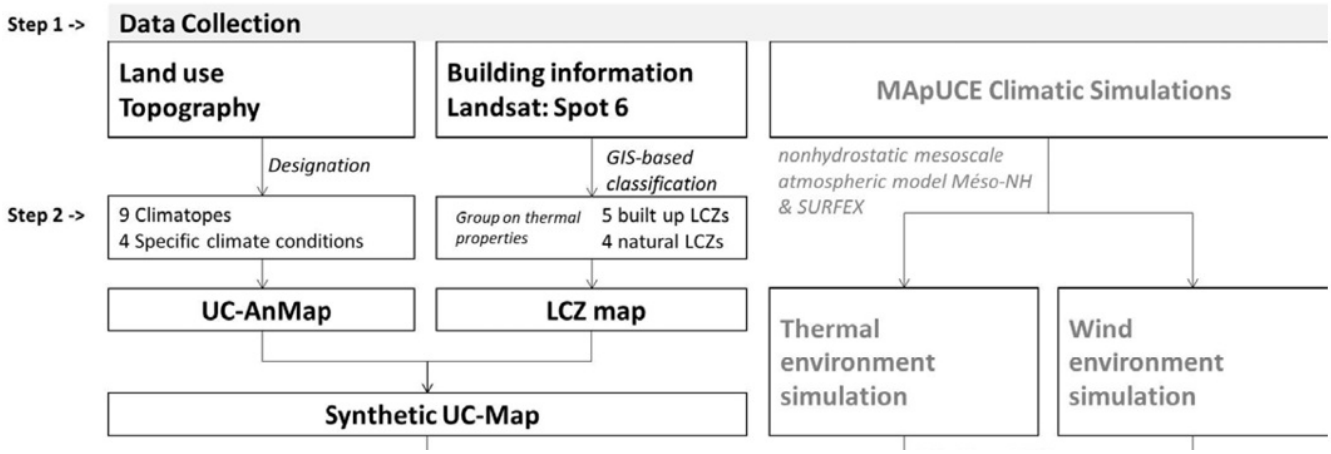
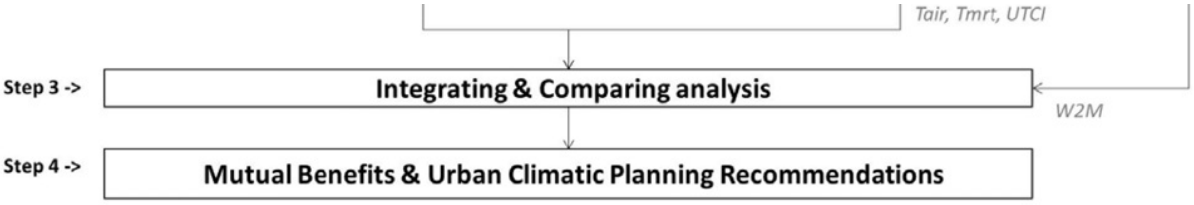
Abstract

The urban climatic map (UCMap) is an implementation-oriented tool for visualizing urban climate information to support urban planning. In contrast, the local climate zone (LCZ) scheme is originally developed for interpreting urban surface information, and linking the characteristics of urban climate and urban morphology at the city level. These two frameworks differ from each other in the aspect of data sources, classification standards, and planning implementation. This study explores the potential of integrating these two complementary frameworks to identify problematic hot spots and propose some generic urban planning recommendations according to current urban climate standards.

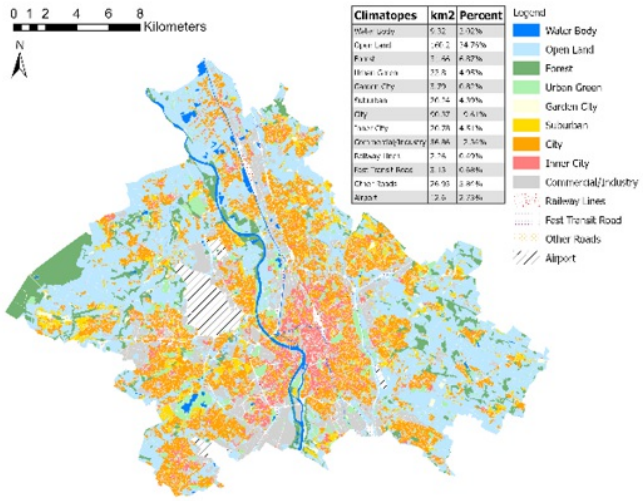
To address this issue, the Toulouse Metropole area, located in southern France, is taken as a case study. A hybrid Climatope-LCZ map is derived by synthesizing the classification of climatopes, based on the German standard (VDI 3787-Part 1), and LCZs at equivalent spatial positions. Furthermore, the simulated meteorological data about wind and thermal environments of Toulouse Metropole during the typical summer season are introduced as evidence for analyzing the mutual benefits on urban climate study and application. According to the results, both the heterogeneous urban geometric characteristics and urban climatic issues within a climatope are well-identified spatially by the corresponding composition of LCZ. Likewise, the differences of thermal stress between climatopes but in the same LCZ are also illustrated. Lastly, a list of urban climatic planning recommendations for LCZs is proposed followed by the guidelines in VDI 3787-Part 1.

This study proves that the hybrid Climatope-LCZ map offers more detailed urban climate information to planners or decision-makers than the original frameworks.

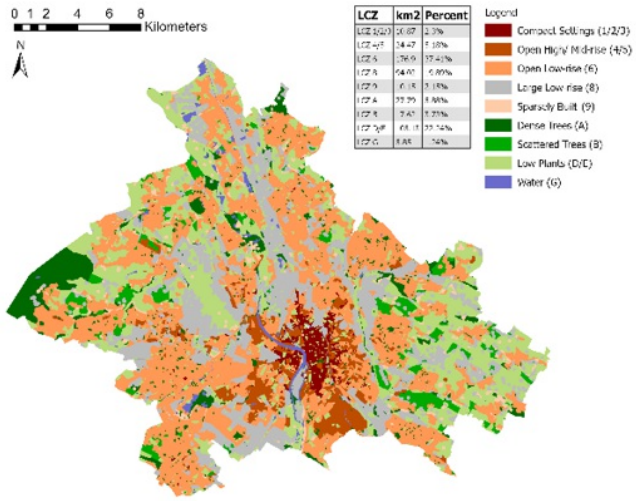




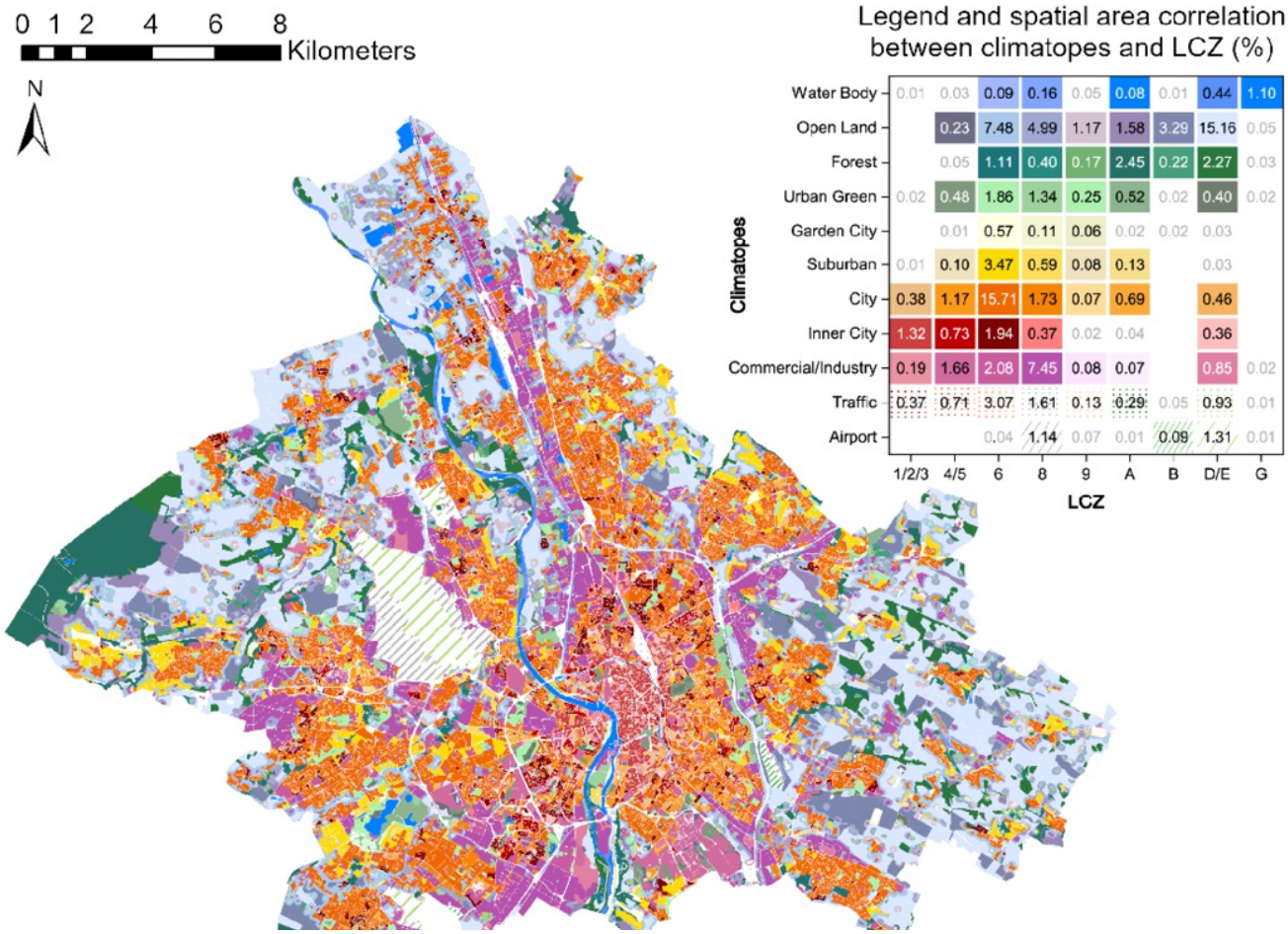
Research steps taken in this study



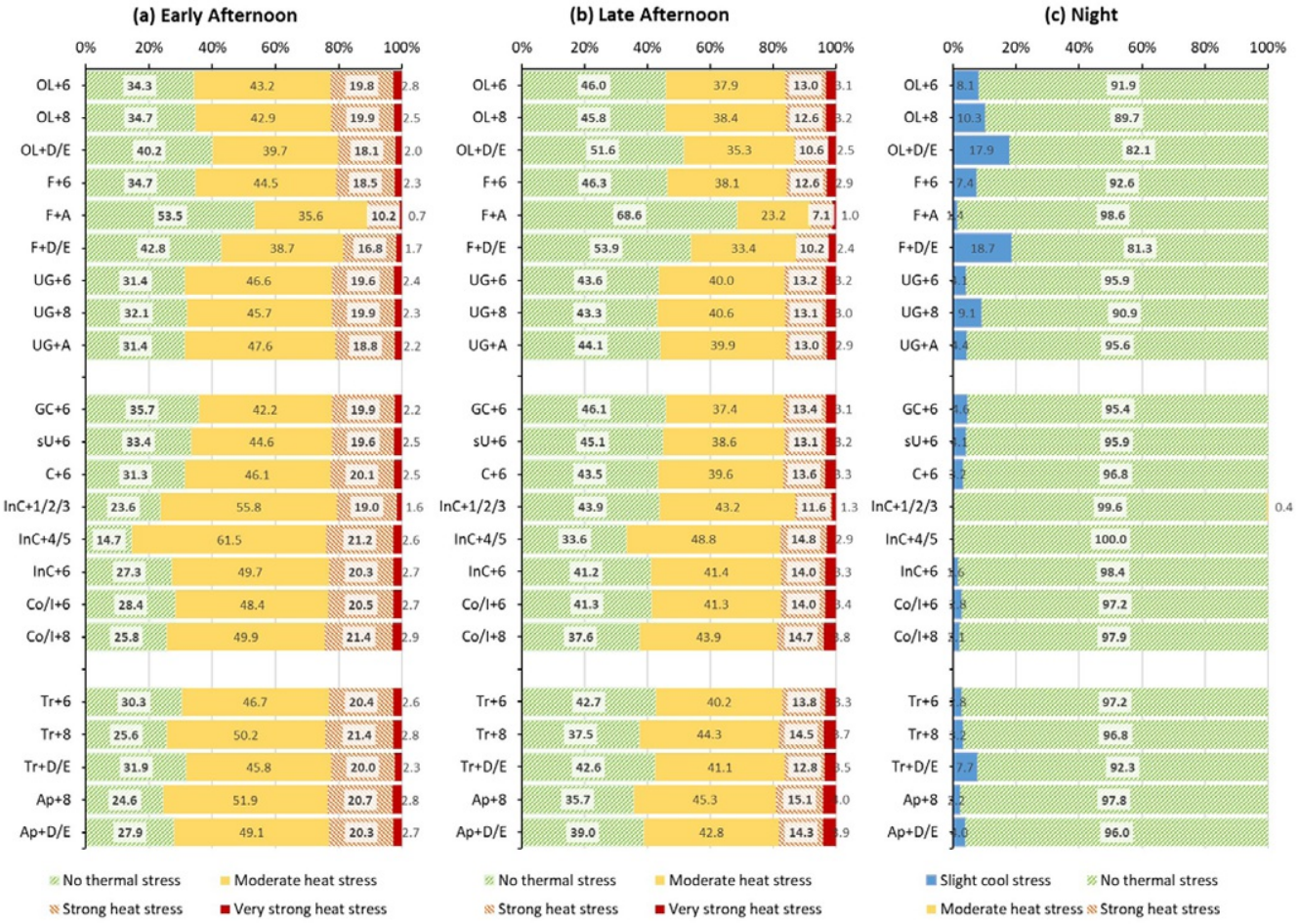
The initial UC-AnMap based on VDI 3787 showing the corresponding areas and area percentages of each climatope.



Grouped local climate zone (LCZ) map of the Toulouse Metropole and corresponding areas and the area percentages for each LCZ group.



Hybrid Climatope-LCZ map and spatial area correlations between the climatopes and the LCZs.



Frequencies of thermal stress occurrence evaluated by the modeled Universal Thermal Climate Index (UTCI) in different LCZs and climatopes during the three time periods: (a) early afternoon, (b) late afternoon, and (c) night.

Session Themes

Urban climate methods: Urban climate informatics

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Overheating adaptations in acclimatised Singaporeans: Do spatial adaptation options matter?

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Abstract

Climate responsive design aims to mitigate extreme heat by consciously integrating climate principles in urban architectures and developments. Thereby, the adoption of climate-responsive design in urban areas is foreseen to increase the adaptation capacities of urban dwellers to overheating. However, behavioural overheating adaptation can also be aspatial (e.g. a change in activity program, clothes, or food regime), and thus not depend on the quality of outdoor spaces. According to the behavioural planned theory, the selection of one of these is determined by the individual knowledge of heat adaptation options, its transaction capacities with its daily routines, and cultural beliefs giving its community belonging.

We investigated the nature of the overheating adaptation strategies in the densely-built city-state of Singapore for different extreme thermal perceptions so as to determine whenever and when space matters in individual overheating coping strategies in a tropical climate and mature tertiary society. We used the records of two biometeorological campaigns aiming to assess the thermal sensitivity of acclimatized Singaporeans, which were, on occasion, extended with a survey questionnaire dedicated to overheating behavioural adaptation. Unsurprisingly, extreme sun, rain, and heat triggered adaptative strategies, while extreme humidity and wind did not. Rain adaptation was mainly aspatial, while extreme sun and heat triggered a mix of spatial and aspatial strategies with more option diversity for the sun than for the heat. Some adaptation options were mutualized as for the air conditioning to cope both with extreme heat and humidity sensations. Last, not all the selected adaptation options reflected the national Singaporean programs aiming to promote outdoors: urban parks, seafront or large water reserves although supporting the “city in a garden” marketing were declared to be less used than naturally and artificially covered roads developed close to house units to foster active mobility.

Session Themes

Biometeorology & health: Urban environmental health

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Quantifying the impact of urbanization and regional climate change in the wintertime surface temperature changes over a rapidly growing tropical city

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Abstract

Climate change due to enhanced greenhouse gas emissions have led to increased temperatures globally. Over urban areas, on top of the regional effects of climate change, there is additional warming due to urbanization. It is often difficult to discern and quantify the local urbanization linked effects and those changes due to climate change over the cities. Generally, the difference between the temperature trends observed over an urban and rural region is considered to quantify the urbanization effect with the assumption that the rural areas are free from the effects of urbanization. However, while using in-situ observations, it is observed that the separation of rural locations devoid of urban impacts is challenging. It is thus difficult to define an urban boundary since most of the cities border on peri-urban regions. Therefore, modeling is an efficient tool to separate these effects. Our study uses a regional climate model to simulate the wintertime surface temperatures over a tropical city and quantifies the effects of urbanization and regional effects of climate change in the observed warming over Bhubaneswar, one of the fastest growing tier II city in India. It was found that the effect of urbanization on temperature is dominant during the nighttime with more than half of the temperature changes attributed to local urbanization effects. Almost 60% of the observed increase in the nighttime temperature is due to the local impacts, and the remaining 40% is due to the regional impacts. By modifying the local land use land cover changes, more than half of the warming observed over the city can be controlled; this has implications for proper urban planning and mitigation techniques.

Session Themes

Urban climate methods: Modelling

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Revisiting the Seasonality of Surface Urban Heat Islands

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Abstract

The difference between urban and rural Land Surface Temperatures (LST)—known as Surface Urban Heat Island Intensity (SUHII)—varies rapidly in space and time as the surface conditions, the weather, and the incoming radiation change. When plotted against rural LST, SUHII exhibits a rate-dependent seasonal hysteresis that strongly depends on local climate conditions. This means that the seasonal variation of SUHII exhibits a looping pattern whose shape is controlled primarily by the local climate and that its magnitude (at any point in time) depends on both present (relative to that timepoint) and recent past effects. This hysteresis is first reported in Zhou et al. (2013-GRSL), where seven distinct and geographically separated types of SUHII hysteresis are identified in Europe. A plausible explanation for the seasonal hysteresis of SUHII is given in Manoli et al. (2020-PNAS), where it is hypothesized that this behavior is the result of time lags between the surface energy budget of urban and rural areas. In this work, we investigate how the SUHII seasonal hysteresis differs across climates and provide a detailed typology of the daytime and nighttime SUHII hysteresis loops. Instead of the typical tropical/dry/temperate/continental grouping, we describe Earth's climate using the Köppen–Geiger system that empirically maps Earth's biome distribution into 30 climate classes. Our investigation covers all the densely populated areas of Earth and uses 18 years (2000–2018) of land surface temperature and land cover data from the European Space Agency's Climate Change Initiative. Our findings show that, in addition to concave-up and -down shapes, the seasonal hysteresis of the SUHII also exhibits twisted, flat, and triangle-like patterns. They also suggest that, in wet climates, the daytime SUHII hysteresis is almost universally concave-up, but they paint a more complex picture for cities in dry climates.

Session Themes

Urban climate methods: Observations

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Evidence of alliesthesia during a neighborhood thermal walk in a hot and dry city

Dr. Yuliya Dzyuban ORCID iD[1], Dr. David M Hondula[2], Dr. Jennifer K Vanos[2], Dr. Ariane Middel[2], Dr. Paul J Coseo[2], Evan R Kuras[3], Dr. Charles L Redman[2]

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Abstract

Designing cities for thermal comfort is an important priority in a warming and urbanizing world. As temperatures in cities continue to break extreme heat records, it is necessary to develop and test new approaches capable of tracking human thermal sensations influenced by microclimate conditions, complex urban geometries, and individual characteristics in dynamic settings. Thermal walks are a promising novel research method to address this gap. During a thermal walk in Phoenix, Arizona, USA, we examined relationships between the built environment, microclimate, and subjective thermal judgments across a downtown city neighborhood slated for redevelopment. Subjects equipped with GPS devices participated in a 1-hour walk on a hot sunny day and recorded their experience in a field guide. Microclimate measurements were simultaneously collected using the mobile human-biometeorological instrument platform MaRTy. Results revealed significant differences in physiologically equivalent temperature (PET) and modified physiologically equivalent temperature (mPET) and between street segments with more than 18°C (25°C mPET) between the maximum and minimum values. Wider range of mPET values reflected the inclusion of individual level data into the model. Streets with higher sky view factor (SVF) and east-west orientation showed a higher PET and mPET overall. Furthermore, we showed evidence of thermal alliesthesia, the pleasure resulting from slight changes in microclimate conditions. Participants' sense of pleasure was related to the mean PET of the segment they just walked, with linear regression explaining over 60% of the variability. We also showed that estimated percent shade was significantly correlated with SVF, PET, mPET, and pleasure, indicating that participants could sense minor changes in microclimate and perceived shade as pleasant. Findings of this study improve the understanding of dynamic thermal comfort in complex urban environments and highlight the value of thermal walks as a robust research method.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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A Predictive Microclimatic Analysis of Pedestrian Thermal Stress in a Densifying Urban Business District – An Eastern-Mediterranean Case Study

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Abstract

A newly introduced master plan in the metropolitan area of Tel Aviv, Israel, calls for the extreme densification of an already intensively built business district. The study aims at assessing the existing thermal stress experienced by pedestrians in the sultry climate of the Mediterranean coastal plain during the summer season, and predicting future changes under various development scenarios. Microclimatic measurements conducted in the summers of 2019 and 2020 served as the basis for an evaluation of the thermal environment using the Index of Thermal Stress (ITS) under present conditions, and possible future scenarios were modelled by hypothetically altering the urban spatial geometry and subjecting the results to a series of sensitivity analyses.

Findings from the modelling study reveal that the net impact of taller buildings and deeper urban canyons is a reduction of pedestrian thermal stress on clear summer days. This is because the deep shading of narrow streets, which lowers the overall radiant heat exposure of a pedestrian, outweighs the negative impact on convective cooling that is expected due to higher air temperature and lower wind speed. Nonetheless, outdoor summer conditions remain thermally stressful during these hours, and common strategies to mitigate urban warming, such as using alternative building and paving materials, were not found to play a significant role in improving thermal comfort in the studied street canyons. Additional shading improves thermal comfort despite the tall buildings, due to significant solar exposure at certain times and street orientations, but available space for street trees is limited. This emphasizes the need for creative solutions for reducing thermal stress, such as building-integrated green infrastructure. Assisting planners and decision-makers with such challenges in densifying business districts is vital, since a more amenable outdoor environment is one of the keys to sustaining urban life in an age of climate destabilization.

Session Themes

Integrated assessments of urban climate : Inter-scale interaction of urban phenomena and climate

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Effects of urbanization on heat stress under relatively dry and wet warm conditions in a semiarid urban environment

PhD Francisco Salamanca, PhD Jennifer Vanos, PhD Matei Georgescu
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Abstract

This research examines the role of urbanization on heat stress intensity (HSI) and wet bulb globe temperature (WBGT) for the two largest urban agglomerations in Arizona (AZ), the Phoenix and Tucson metropolitan areas, using the WRF model. We simulate meteorological conditions during relatively dry and wet summer (June, July, and August) periods at high spatial resolution (i.e., 2-km horizontal grid spacing). The selected three-month periods represent the driest and wettest summers from a 15-year contemporary period (2007-2021) based on the Climate Prediction Center Unified Gauge-Based Analysis of daily accumulated precipitation over AZ. Urbanization impacts are assessed by performing two identical WRF experiments for each summer with different land use-land cover (LULC) representations: one WRF simulation with the current urban LULC (WRF_URB) and one WRF simulation (WRF_NOURB) using a replacement of all urban grid cells with the dominant regional land cover type (i.e., open shrublands). Contemporary urban LULC is characterized by using the US Geological Survey 30-m 2019 National Land Cover Dataset, which recognizes four urban categories based on the concentration of buildings (i.e., developed open space areas, low intensity areas, medium intensity areas, and high intensity areas) and the fraction of impervious surfaces. These four urban classes are subsequently grouped into three urban categories: low-intensity residential (LIR), high-intensity residential (HIR), and commercial or industrial areas (COI). The Noah LSM and the multilayer building energy model MBEM coupled to WRF provide the lower boundary conditions from the natural and urban surfaces, respectively. The urbanization impacts on HSI and WBGT are estimated from the difference between WRF_URB and WRF_NOURB simulations. Our analysis extends to a quantification of the number of heat caution hours (i.e., number of hours in a day that HSI and WBGT exceed a particular threshold) that ensue as a result of the presence of urban surfaces.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Urban canopy, heat and health in Adelaide: Identifying possible hotspots of inequality

Dr Carlos Bartesaghi Koc ORCID iD, Prof Veronica Soebarto ORCID iD, Dr Scott Hawken ORCID iD, Dr Ehsan Sharifi ORCID iD
University of Adelaide, Adelaide, Australia

Abstract

Extreme hot weather and unprecedented heatwaves are threats that result in hundreds of deaths every year across Australia. Green infrastructure, particularly urban tree canopy, has the capacity to reduce urban temperatures and mitigate the health burden caused by heatwaves. There are increasing number of studies assessing the influence and benefits of urban greenery on human health; however, there is no record of research conducted for Adelaide that have thoroughly investigated the explicit spatial associations between urban tree coverage, heat-related mortality (HRM) and socio-economic vulnerability levels. This study analyses the geographical patterns of urban canopy and HRM among vulnerable populations including children, older and indigenous within Greater Adelaide Metropolitan area, and assesses the role of some socio-demographic risk factors associated with it.

Using data from population health areas (Statistical Areas Level 2 and 3), the present study employs epidemiological techniques to evaluate the spatial variability and relationships between the potential increment of tree coverage, potential reduction of HRM rates, various socio-economic and demographic risks factors, and causes of premature and potentially avoidable death. This will facilitate the identification of possible hotspots of inequality across the metropolitan area of Adelaide. Results provide dramatic public health benefits from the potential increment of tree canopy coverage in areas with evident socio-economic and cultural inequality. These results can ultimately support public health policies with urban planning and greening strategies for the entire metropolitan area and specific local governments to increase liveability and thereby help reduce the health burden and risk of deaths particularly among vulnerable populations in the future.

Session Themes

Biometeorology & health: Urban environmental health

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Characterizing atmospheric stability using Radon-222 for UHI studies: Central Poland case study.

Dr Agnieszka Podstawczyńska ORCID iD[1], Dr Scott D Chambers ORCID iD[2]

[1]University of Lodz, Faculty of Geographical Sciences, Department of Meteorology and Climatology, Lodz, Poland. [2]Environmental Research, ANSTO, Sydney, Australia

Abstract

This investigation extends a previous urban climate study using the natural radioactive gas 222Rn (radon) to improve our understanding of urban canopy processes on diurnal to seasonal timescales and verify radon's utility as a valuable tool for detailed quantitative characterization of urban canopy influences on local climate parameters. A radon-based technique was used to characterise the local (25-50 km scale) nocturnal atmospheric mixing state, from which daily (24-hour) mixing "class types" were assigned for the purpose of separately investigating meteorological and urban design contributions to changes in urban climate.

Four years (2008-2011) of hourly near-surface meteorological and radon measurements (AlphaGUARD® PQ2000PRO) from adjacent urban and rural sites were analyzed. The urban station was in the centre of Lodz (ca 725,000 inhabitants, area 293 km2). The rural station was 25 km to the north, in the district of Ciosny, and is representative of typical agricultural land with low vegetation and sparse dwellings.

The radon-based technique was employed to characterise the Urban Heat Island Intensity, near-surface temperature gradient, wind speed, and humidity over the diurnal cycle for each mixing "class type". This technique is demonstrated to be an effective tool for: improved understanding of urban canopy influences on local climate and consistently assessing the efficacy of urban heating mitigation measures over timescales of years to decades.

The consistency of the radon-based approach, ease of application and unprecedented clarity of findings, provide a strong argument for radon observations to be included in the 'standard measurement suite' for urban climate monitoring networks for non-coastal cities.

Session Themes

Urban climate methods: Observations

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Evaluation of Urban-Scale Simulations of a Sydney Supercell Storm

Dr Asiful Islam ORCID iD[1], Dr Charmaine Franklin ORCID iD[2], Dr Vinod Kumar ORCID iD[2]
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Abstract

To understand the impact of grid resolution on the Unified Model's ability to represent convection, km- and sub-km scale simulations were conducted for a supercell thunderstorm case over greater Sydney, New South Wales. The limited area simulations were driven by the Bureau of Meteorology's global Numerical Weather Prediction (NWP) model, and the analysis presented is for simulations with horizontal grid lengths of 1.5 km, 333 m, and 100 m. The sub-km simulations have stronger updrafts, a smaller fraction of low cloud and earlier initiation of rainfall. The diurnal variation in 1.5 m temperature and dewpoint is well captured by all the simulations relative to observations, with a small positive bias in mean air temperature. Comparison against blended radar-gauge rainfall observations show that the 100 m simulation has less rain with mid-low rain rates below 8 mm/hr and has a smaller number of total raining grid boxes. Both sub-kilometre simulations underestimate total rainfall compared to the 1.5km simulation, which could be due to the smaller domain size used in the sub-km simulations limiting the development of convection, or the misrepresentation of convective storm dynamics with updrafts possibly being too strong and not entraining enough dry air. This simulation and analysis framework using case studies of extreme urban weather events is also being used to evaluate land surface and urban morphological datasets.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

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A machine learning approach to study the relationship between urban morphology and urban heat island

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Abstract

Urban heat island effect is a common phenomenon in cities, with urban temperatures being higher than their rural counterparts. Traditional ways to study this phenomenon include mesoscale meteorological modeling and in-situ measurement. The drawbacks of these approaches include high computational costs, model uncertainties, high maintenance costs, and the sparsity of the observation network. With the recent advancement in AI algorithms and open-source databases, the combination of machine learning and remote sensing technique could provide an alternative to tackle the problem.

In this study, the Land Surface Temperature (LST) images and urban morphology data over the Pearl River Delta (PRD) region in China are gathered. Two types of machine learning models - Deep Neural Network (DNN) model and the Random Forest (RF) model, are compared – in terms of their capability to estimate the LST over different regions over the PRD by providing the model with relevant geographical and urban morphological statistics (for example, different values of urban canopy parameters (UCPs)). We compared the results from both models and found that urban morphology is important in improving the performance of the models. Moreover, the RF model is found to have both higher accuracy, higher stability, and greater efficiency than the DNN model in predicting LST. The seasonal variations of the performance of the RF model were also analyzed.

Our final model has a high correlation between its predicted LST value and the true LST value with a mean error of less than 1 degree Celsius, indicating that our model has a good ability to quantitatively analyze the relationship between urban morphology and the urban heat island effect, which would be useful for urban climate studies.

Session Themes

Urban climate methods: Urban climate informatics

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What is the impact of urban climate on indoor heat stress? - Simulation results with urban climate and building models

Dr. Astrid Ziemann ORCID iD[1], Dr. Christoph Schünemann ORCID iD[2], Dr. Valeri Goldberg ORCID iD[1]
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Abstract

How do micro-scale climate conditions differ across urban neighborhoods? Do spatial differences in urban climate have a significant effect on indoor climate? Does the location of buildings have an effect on indoor thermal comfort? These issues are becoming increasingly important for municipal planners, among others, as climate change continues. Especially in dense metropolitan areas, heat stress for residents will increase due to more frequent and intense hot spells. In order to quantify the associated thermal stress in indoor spaces and to derive effective adaptation measures, a model chain was applied within the project Heat Resilient City. The climate models ENVI-met and HIRVAC and the thermal building simulation model IDA ICE were applied in a founder time quarter in Erfurt.

The simulation results clearly indicated that appropriate meteorological model data are crucial as input values for building simulations and robust simulation results. Requirements for the quality of climate model data were investigated with the model chain. The sensitivity studies with the models focused on the diurnal variability of air temperature, among other things, and the range of values of meteorological variables, including global radiation. The aim of the studies was to derive low-threshold adaptation measures to heat periods for indoor spaces. It was shown that realistic daily variations and maximum values of air temperature and global radiation lead to a moderate thermal load in indoor spaces. Night cooling by opening windows and cross ventilation were quantitatively evaluated and recommended as appropriate measures to reduce the nighttime thermal load on occupants. Depending on the location of the building and the rooms in relation to the wind direction, night ventilation is more or less effective. In addition, incident solar radiation affects the thermal load at night. Shading in the exterior space or sun protection can effectively reduce the energy input into the building.

Session Themes

Urban climate methods: Modelling

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How do local heat islands depend on horizontal superelevation? Analysis of model simulations in urban neighbourhoods of the cities of Dresden and Erfurt (Germany)

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Abstract

In this study functional relationships between urban morphological parameters and meteorological data were considered to identify local heat islands and derive effective adaptation measures of summer heat for open space and building design.

For this purpose, model simulations with SOLWEIG and ENVI-met were carried out and evaluated for two urban districts in Dresden and Erfurt (Germany). Based on this, relationships were determined between parameters from digital object models (DOM) and variables of thermal exposure (Mean Radiant Temperature Tmrt, Universal Thermal Climate Index UTCI).

For the local heat island effect and its spatio-temporal variations, the Sky View Factor (SVF) plays a key role. The SVF is important for determining the radiation balance in models and thus Tmr at a location. In order to represent the influence of the SVF on Tmrt, it is essential to describe the urban morphology and vegetation as detailed and up-to-date as possible with the help of high-resolution DOMs. The higher the SVF, the more insolation occurs during the day. At the same time, a higher SVF also ensures greater radiation at night and can thus reduce Tmrt and heat stress. The Tmrt averaged over the day hours shows the highest values in unshaded (high SVF) or south-facing exposed locations as well as in open squares and courtyards or streets facing west-east. Here the heat load, expressed with the UTCI, is also maximum during the day. Places with low Tmrt are found during the day where the SVF is very low, e.g. in the shade of trees.

In contrast to buildings, vegetation elements have a partial transmittance to shortwave and longwave radiation leading to changed interactions of SVF with Tmrt. For this reason, different statistical relationships between SVF and Tmrt were derived for green and grey urban infrastructure to determine local heat island effects more reliable.

Session Themes

Biometeorology & health: Methods, applications, and translational research

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Land Cover Impacts on Surface Urban Heat across Different Climates

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Abstract

Urban areas with distinct climatic conditions and surface characteristics have different thermal environmental requirements. Several studies have explored the effects of land covers on urban heat across individual cities. However, a quantitative understanding of how background climate affects the thermal impact of urban land covers is still lacking. Accordingly, a consistent global investigation with a high spatial resolution is needed to identify the controlling factors of intra-urban temperature variability in cities located in different climatic regions. For this purpose, this study focuses on characterising different land covers in more than 50 populated cities (using Landsat 8 data) and aims to explore their effects on Land Surface Temperature (LST) variability in various climate zones. Results showed that urban surface characteristics in arid cities were significantly different from other climate classes. In addition, the dominant factors of LST variability in arid and tropical climates did not show a significant seasonal variation. In contrast, in cold and temperate climates, the determinants of LST were season-dependent, especially for cold climate. In tropical, temperate, and cold climates, NDBI is the strongest determinant of the variability in LST during warm periods, followed by NDVI, while NDBaI is the most important factor in arid climate, followed by NDBI and Albedo. In temperate and cold climates, NDVI and NDBI are less influential in explaining LST variations during cold months, whereas NDBaI, Albedo, and terrain variables (distance from the coast and elevation) are slightly more important in this period compared to warm months. These findings provide a theoretical climate-sensitive basis for future urban planning oriented at mitigating local climate warming in cities.

Session Themes

Integrated assessments of urban climate : Urban climate and climate change

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Investigation of industrial heat transmission between two land masses in a tropical city of Singapore

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Abstract

Tropical city of Singapore has complex urban morphology and heat emissions from core industry in the Jurong Island (JI) may impact the surface energy budget of the main island. An algorithm is implemented in the existing land surface model of Weather Research and Forecasting (WRF) model that accounts for the anthropogenic heat emissions from traffic, power plants and industry in addition to the existing mechanism in WRF that determines the anthropogenic heat from buildings.

A novel technique utilizing knowledge graph is used to generate the data for the various industries JI. After performing necessary data quality checks and considering specific climatic conditions a reliable data set is generated that is utilized to initialize WRF with the industrial heat emissions.

In the absence of strong prevailing wind and increased wind variability the main island is rarely impacted by the heat emissions except under certain specific maximum conditions minimum impact is noticed. However, under strong prevailing wind, the western part of the island is mostly impacted in the direction of the prevailing wind. It is concluded that JI is a complex area with interaction of water, urban areas and high AH emission which affect air temperature in the mainland when wind has a southern component. Higher impact is expected during SW-monsoon season (July). Outside JI, the highest impacts tend to occurs during night-time in the nearby areas, close to JI. Changes in circulation patterns can also increase ventilation in close urban areas, and reduce urban heat accumulation. Mean values show a low impact in the urban heat island (UHI) of Singapore. JI can contribute ~ 10% to the mean urban heat in nearby mainland. Some extremes can happen reaching 1°C (specific days and hours, NOT mean values) due to changes in circulation pattern (April) and advection (July).

Session Themes

Urban climate methods: Modelling

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AN URBAN CLIMATE WALKING TOUR AS AN INSTRUCTIONAL TECHNIQUE FOR LINKING TOGETHER DIVERSE ASPECTS OF URBAN SUSTAINABILITY

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Abstract

Whilst the application of urban climate knowledge as both an urban planning consideration and as energy management parameters are increasingly identified as critical drivers towards climate responsive urbanism, there is a low up-take of this evidence being incorporated into city plans.

It could be argued these oversights result from the interplay between a buildings' external and internal environments as complex, site-specific, and little-understood, therefore it is unreasonable to expect policy to go beyond scientific understanding. Yet what is known is not regulated, and well-understood relationships are not accounted for.

Our research suggests that these spatially complex relationships between indoor and outdoor climates are not clearly understood, and to address these oversights we require an interdisciplinary approach that integrates existing urban knowledge and terminology at a fundamental level.

Here we report on a novel dissemination activity 'an urban climate walking tour' which has developed to demonstrate (first-hand) urban climate research to a wide range of built environment practitioners, whilst drawing attention to many of the built form outcomes which currently fall outside the broader discussion on sustainable urban development.

The walk provides a mechanism to generate an interdisciplinary narrative to overcome the barriers to the uptake of urban climate research by focussing on physical experience to complement a theoretical understanding of wide range of urban effects. The walk provides a coherent and integrated approach towards understanding the complexities of urban systems linking urban disciplines at a scale greater than the individual building.

Currently Urban Climate Walking tours that have already adopted this methodology include the City of London; and the City of Westminster; Birmingham (UK); Sao Paulo, Brasil; Borlänge, Sweden, with new walks planned for Cardiff, Barcelona and Paris.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Evaluating the accuracy of black-globe thermometer to determine mean radiant temperature on human thermal comfort in summer

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Abstract

With respect to the analysis of human thermal comfort in the field of urban and landscape planning, mean radiant temperature (T_{mrt}) is the most important parameter among the main micro-meteorological key factors (Lee et al., 2021). The dominant influence of T_{mrt} on human thermal comfort leads to the requirement of precise determination of T_{mrt}. However, due to the price advantage, black-globe thermometer is to be still applied for the determination of T_{mrt} comparing to the method of net-radiometer, which is recently used in the field of human thermal comfort worldwide.

In this study, the usefulness and accuracy of the 150 mm diameter black-globe thermometer for measuring Tmrt were verified by the field measurement of the CNR4 Net-radiometer. The field investigations were conducted on the clear-sky summer days at two different measurement points: i) Hyowon park in Suwon on 10-11 August 2016, 09:00-21:00 and ii) Woljeong-ri beach in Jeju on 23-24 August 2016, 09:00-17:00. As a result, the coefficient of determination between the black-globe thermometer and the CNR4 Net-radiometer results shows an acceptable correlation (r^2=0.81). However, the accuracy was significantly low when T_{mrt} was over 45 °C. Consequently, the black-globe thermometer should be applied very carefully to determine human thermal comfort in summer due to the serious difference of up to 10.1 °C physiologically equivalent temperature (PET).

<Reference>

Lee, H., Jo, S., Park, S., 2022. A simple technique for the traditional method to estimate mean radiant temperature. Int. J. of Biometeorol. 66(3), 521-533.

Session Themes

Biometeorology & health: Methods, applications, and translational research

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Laboratory Level Test Setup for Studying Cool Coating Effect on Street Canyon’s Air Temperature Using Reduced Scale Model

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Abstract

The study describes the design and development of a novel laboratory scale-model test setup for studying the contribution of urban fabric (buildings, pavements and other urban built-up surfaces) on urban heat island (UHI) effect. The setup is developed with an objective to model absorption, storage and release of heat from the urban fabric, a key aspect in studying the UHI phenomenon. Direct and diffuse components of spectral solar radiation, ambient thermal conditions and building material properties are simulated with the help of scale similarity theories applied in this research. Experiments are conducted using 1:100 scaled models of a real scale street canyon. Validation of measurements from the scale model is presented by comparing the results with real-scale experimental results. Analytical methods have been used to compliment the experimental results of the scaled model. The peak reduction in road surface temperature observed in the reduced scaled model (H/ W =1) was up to 6.3°C, for the East-West canyon orientation whereas it was only up to 1°C for the North-South Orientation due to limited exposure duration of direct radiation in the N-S direction. The corresponding reduction in canyon air temperature reduction due to cool surface was up to 1°C for the E-W orientation and whereas for the N-S orientation it was only up to 0.2°C.

Session Themes

Urban climate methods: Modelling

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Temporal and Spatial Variation of Anthropogenic Heat Emissions in Colombo, Sri Lanka

Dr Lewis P Blunn ORCID iD[1], Mr Xiaoxiong Xie ORCID iD[2], Dr Ting Sun ORCID iD[3], Dr Narein Perera ORCID iD[4], Prof Rangajeewa Ratnayake ORCID iD[4], Prof Rohinton Emmanuel ORCID iD[5], Dr Zhiwen Luo ORCID iD[2], Prof Sue Grimmond ORCID iD[2]

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Abstract

The anthropogenic heat emissions of lower-middle income, low-latitude countries are rarely studied in detail. Given the importance of these heat emissions to local building design, net zero-carbon, and human health (e.g., heat stress), it is important to have a benchmark to assess the feedbacks of decisions at the local scale and beyond. Here we focus on Colombo, Sri Lanka. Detailed land cover and morphology are developed, and the temporal variation of energy consumption is examined. This allows much greater understanding of anthropogenic heat emissions in this type of city compared to previous studies.

The anthropogenic heat emissions have little seasonal variability, a small mean magnitude (6.6 W m^{-2} at 100 m scale) with proportionally large diurnal variability. Weekdays vary between a maximum of 18.2 W m^{-2} and a minimum of 2.0 W m^{-2}, with three distinct peaks in the day. This differs from the two typically found in mid-latitude cities. Metabolic, building, and transport related emissions comprise 40, 31, and 29 % of the total, respectively. Emissions from buildings are proportionally small (cf. mid-latitudes), as there is no requirement for space heating, air conditioning is rarely used, and there is little heavy industry. When analysed on a 100 m grid there is large heterogeneity in fluxes (maximum value of 146 W m^{-2}), but fluxes become much more homogeneous with aggregation. Projections of anthropogenic heat flux from 2020 to 2035 range between 24 and 61 % increase.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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The effect of the microclimate of the city of Helsinki on carbon sinks

Minttu Havu ORCID iD[1], Liisa Kulmala ORCID iD[2,3], Hei Shing Lee ORCID iD[1], Jesse Soininen[1], Leena Järvi ORCID iD[1,4]

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Abstract

A significant proportion of cities will strive to become carbon neutral in the coming decades by reducing emissions, although more and more cities are including carbon sequestration in their plans to offset emissions. Urban green areas have potential to sequester carbon, however, quantifying the magnitude can be challenging. Our knowledge on biogenic carbon cycle is mainly based on data and models from natural ecosystems, although urban areas and their microclimate can vary from those. Modelling tools that take into account these factors are needed to better quantify the carbon sequestration potential of urban green areas.

The aim is to estimate the carbon sequestration potential of urban vegetation and soil of the city of Helsinki, Finland. The Surface Urban Energy and Water balance Scheme (SUEWS) has a recently developed carbon dioxide (CO_2) module that simulates local anthropogenic emissions and biogenic components. The module has been parameterized and evaluated against measurements in Helsinki. As SUEWS is able to simulate the local 2 meter air temperature, the warmer temperatures in compact urban areas can be considered. The city is divided into 250x250 m^2 grids, and in each grid, SUEWS is run over two year period (2020–2021) with hourly resolution. The local anthropogenic CO_2 flux is also estimated to compare the magnitudes of biogenic sinks to anthropogenic sources. The soil carbon model Yasso is also used to estimate the variability of soil carbon respiration in urban areas, as SUEWS has only a simple soil model to estimate CO_2 emissions from soil. Yasso will be run for longer period to capture the changes in soil carbon stocks. The forcing meteorology is from reanalysis products, however, the simulated local 2 meter temperature with SUEWS will be used to force the soil carbon Yasso model to catch the warmer temperatures in urban areas.

Session Themes

Urban climate methods: Modelling

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Lowering the temperature to increase heat equity: A multi-scale evaluation of nature-based solutions in Toronto, Ontario, Canada

Dr. Vidya Anderson ORCID iD[1], Professor William A. Gough[1], Mr. Matej Zgela[2], Dr. Dragan Milosevic[3], Dr Jelena Dunjic[3]

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Abstract

Nature-based solutions present an opportunity to reduce rising temperatures and the urban heat island effect. A multi-scale study in Toronto, Ontario, Canada, evaluates the effect of nature-based solutions (NbS) such as green infrastructure on land surface (LST) and air temperatures through two field campaigns at the micro and meso scales, using in-situ measurements and LANDSAT imagery. The results of both data collection campaigns demonstrate that green infrastructure has a beneficial impact on near surface air temperatures and LST at the micro and mesoscales. Analysis of the data collected to measure the potential of green infrastructure to regulate near surface air temperature and LST is consistent with the hypothesis that multiple types of green infrastructure can reduce warming temperatures in Toronto, Ontario, Canada, regardless of location, geography, or land use type. Accordingly, broad implementation of green infrastructure could be a sustainable solution to improve urban climate, enhance heat and green space equity, and increase resilience.

Session Themes

Special Session: Integrated urban climate services for equitable heat resilience: Integrated urban climate services for equitable heat resilience

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WRF-comfort: Multi-scale quantification of the spatial variability of pedestrian thermal exposure

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Abstract

Urban outdoor thermal comfort depends on air temperature, humidity and exposure to wind speed and radiation (as quantified by the mean radiant temperature, Tmrt). While air temperature and humidity vary at scales of several hundred meters, wind and radiation vary at scales of 1-10 m due to sheltering and shading by buildings and other obstacles. Moreover, city-regional scale processes influence temperature and humidity, and require meso-scale modelling. Current computational power limits our ability to capture fine scale radiation and air flow processes on model domains sufficiently large to capture these city-regional scale processes. Here, we use micro-scale modelling to develop relations between grid-scale wind velocity and micro-scale spatial variation of wind speed. Secondly, we develop a model of pedestrian radiation exposure capable of quantifying the range of Tmrt within a neighbourhood (i.e. at the grid scale) and embed it in the BEP multi-layer urban canopy model within the WRF meso-scale model. The combined pedestrian thermal exposure model, WRF-comfort, is evaluated and applied to a case study in Madrid, Spain.

Session Themes

Integrated assessments of urban climate : Inter-scale interaction of urban phenomena and climate

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Examining the Effect of the Configuration of Urban Design Elements on Outdoor Thermal Conditions in Urban Spaces, Case Study: Tehran

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Abstract

Urban public spaces are the heart of the cities in which people are able to engage in plenty of social activities like communicating with each other, resting, watching people, and playing games. However, nowadays, in the era of climate change, these spaces directly suffer from the sensible changes that happened in the weather in short term and climate in long term. While the speed of the change is relatively fast, urban planners and designers can manipulate the physical aspects of the urban areas to improve the quality of comfort in open spaces to motivate people to spend more time outdoors. This study aims to compare the effectiveness of different urban design solutions in the enhancement of heat stress in the 17th Shahrivar pedestrian way in Tehran. To reach this goal, physical aspects of urban spaces like vegetation, water, width to height ratio, and material, that can affect thermal condition, were utilized. Then a simulation model of the area was provided by the ENVI-met software to present different scenarios and their influence on air and surface temperature. In conclusion, results showed that providing shadow is the most effective way to improve the microclimate in the hot and dry climate of Tehran, particularly in summer. It also can be seen that the configuration and types of urban design elements can significantly change the effectiveness of different shadowing scenarios.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Impact of planned urban expansion on the urban heat island intensity

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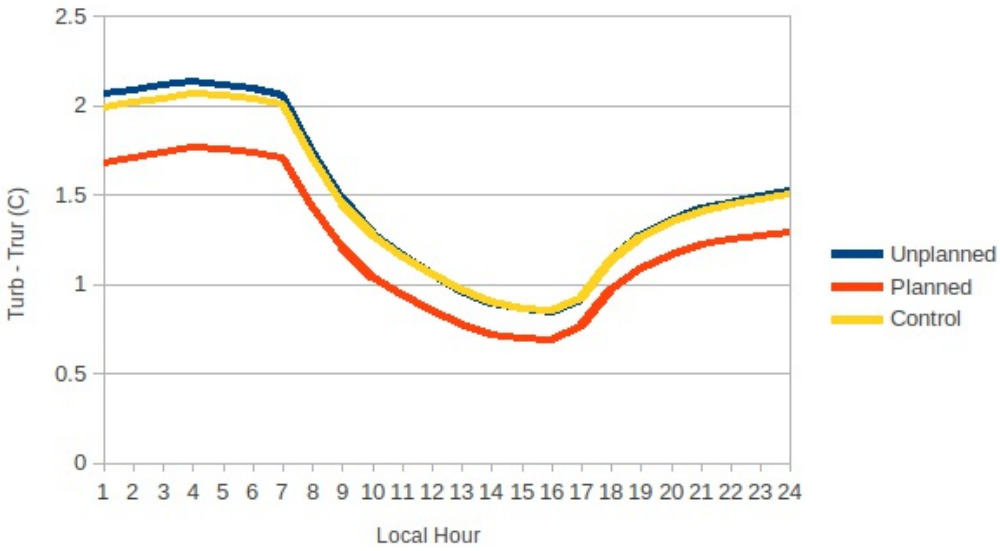
Abstract

Urban Heat Island (UHI) is a microclimate phenomenon in urban areas, where the air temperature is higher than the surrounding rural areas. The urban population is growing and so are cities. Ribeirao Preto is a city in the southeast part of Brazil that has a growth rate higher than the national average. An unplanned expansion may lead to a more intense UHI effect. Our goal is to determine the impact of urban expansion on Urban Heat Island Intensity (UHII) in two scenarios: a planned expansion, prioritizing greater vegetation fractions, and an unplanned expansion. We performed three simulations, using the Weather Research and Forecasting (WRF) meteorological model, of a clear weather winter day in Ribeirao Preto: the control simulation used the land use MODIS classification and only one urban class; the unplanned urban expansion simulation used a 30% increased urban area; the planned expansion used the same increased area, but using the open low-rise Local Climate Zones (LCZ) class in this extra area. Results show that the unplanned urban expansion did not increase the UHII, probably because the area that was changed to urban was not very vegetated. However, the UHII for the planned urban expansion is lower than for the unplanned urban expansion for the whole period, reaching a maximum difference of 0.39°C. We concluded that the urban planning may be used to mitigate the UHII, particularly if it prioritizes low-rise buildings and an increase in vegetation.



Session Themes

Urban climate processes: Boundary layer and urban canopy layer processes

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Assessing hurricane wind fields to predict areas of wind damage to cities along the Gulf of Mexico

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Abstract

Hurricanes are tropical cyclones with maximum sustained winds of at least 74 miles per hour that can be felt tens of miles away from the storm's center. These intense winds cause far-spread infrastructural destruction that impacts the quality of human life. The Gulf of Mexico is accustomed to hurricanes, with the area experiencing some storms that have sometimes cost over a billion dollars. The excessive costs and the loss of life are drivers in providing solutions to comprehend hurricane-wind damage. The significance of this project is to show that being able to use Geographic Information System (GIS) tools can help foresee areas of hurricane wind damage when the size of the storm is known. A buffer, a spatial tool within GIS, measures a distance outward from a specific point. In this poster, a buffer creates cones around previous hurricane tracks. This will be used to create visual deliverables in the form of maps showing a potential wind field generated by hurricanes. GIS allows for better planning and communication and provides the visualization to discuss probable localities of impact. This research aims to demonstrate the potential damage by wind-generated hurricanes impacting states along the Gulf of Mexico (Alabama, Florida, Louisiana, Mississippi, and Texas) using buffers. Within the cones, the effect on cities and their populations at the time of impact will be determined. Buffer size was calculated using the determined size of each storm, along with the length of hurricane-force winds that can be felt from the storm. The utilization of GIS technology in hurricane-force wind-field prediction can lower the likelihood of damage to both assets and human life. Understanding the field of hurricane-force winds will lead to more sustainable and resilient coastal communities.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

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Parameterization of thermal buoyancy on the exchange velocity of urban canopy layer

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Abstract

Thermal buoyancy plays an important role in urban ventilation, especially in low wind scenarios, when extreme urban heat and pollutant accumulation events appear. The accuracy of urban canopy layer (UCL) models relies on the parametrization of exchange velocity, which quantifies the mass and heat exchange rate between the urban canopy layer and aloft spaces. Currently, the correlation between the urban morphology and meteorology parameters to the exchange velocity has been well established. However, the buoyancy effect is largely ignored. This study aims to parameterize the buoyancy effect on the exchange velocity of UCL via high-fidelity Large Eddy Simulation (LES). In the first step, three representative urban morphologies are selected based on the statistical urban densities of Singapore. In the second step, CFD simulations are conducted with 12 different heat emission intensities and three representative urban morphologies. In the third step, the exchange velocities are calculated in a UCL unit. The buoyancy coefficient, which indicates the increment of exchange velocity caused by thermal buoyancy, and its correlation with heat flux and urban morphology is then obtained. An empirical formula is built to calculate the buoyancy coefficient, which is a function of urban morphology and heat emission rate. An analytical model is then developed based on the empirical formula of exchange velocity and heat conversation at the urban canopy layer. With the new analytical model, both steady-state air temperature increment and transient period in the street canyon can be easily estimated by urban planners with GIS data. Using this new tool, we calculate the air temperature increment in the whole Singapore due to anthropogenic heat emission. The transient time of the air temperature increment under a step-up anthropogenic heat-releasing condition indicates that higher urban density could trap more anthropogenic heat and make the heat stay longer in the UCL.

Session Themes

Urban climate processes: Boundary layer and urban canopy layer processes

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Hectometric modelling of urban and atmosphere environment interactions during a heavy precipitation event over Paris

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Abstract

Climate change and a rapidly increasing urban population make cities more vulnerable to hazardous weather events. The need for a better understanding of meteorological processes in an urban environment is crucial to mitigate these impacts and protect the population.

Advances in convection-permitting atmospheric models combined with improved urban description help better describe the urban heat island and its potential effects on convective precipitation. Many publications investigated the interactions between urban environments and thunderstorms but conclusions remain ambiguous regarding the rainfall change downwind or upwind of the city. The main strategies to study the impact of urbanization on precipitation are climatologic or specific case approaches.

The objective of this study is to investigate the effects of the Paris urban environment on the thunderstorms causing floods in Paris on 7 July 2017. Hereby the key meteorological elements in the atmospheric boundary layer as well as in the upper levels are considered. An ensemble of numerical simulations is built using the Meso-NH research atmospheric model initialized and forced by either AROME or IFS analyses. Through the nesting technique in a two-way mode, these analyses are gradually downscaled, featuring hectometric grid spacing modelling. A multi-layer urban scheme is applied to better represent the building drag effect on the flow of thunderstorms. Then two sets of ensemble simulations are performed to identify the main processes driving the interactions: one with a fine-scale surface description of the city and another one where the urban surface is replaced with vegetation.

The first results show that it remains challenging to correctly simulate the location of thunderstorms. Nevertheless, the ensemble technique combined with urban and no urban city description is effective to highlight the urban environment impacts on thunderstorms.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

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Heat and cold urban islands and its effects on thermal comfort in the tropical coastal city of Fortaleza (Brazil)

PhD Isabel Ribeiro[1], PhD Jorge Humberto Amorim[1], Júnior Lima[2], Maria Elisa Zanella[2]
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Abstract

The thermal comfort in cities is closely dependent on the urban physiography characteristics. In addition to the urban heat island effect, the predicted increase in air temperature as a result of climate change leads to the importance of defining and implementing effective adaptation plans to make cities more pleasant to live in. In this context, we are focused on understanding the relationship between urban climate and physiography, and how they affect human thermal conform, to provide useful information for a more sustainable urban planning in a climate change context in tropical cities.

The dynamical downscaling was performed with the regional model HCLIMcy38, up to 1km horizontal resolution, which integrates SURFEX for a more accurate simulation of the surface fluxes. The land-cover was refined based on Local Climate Zones. Measurement campaigns, and meteorological data from five recent-past years representing different climate conditions are used to study different intra-urban thermal clusters.

Three different environments within the urban area of Fortaleza are taken as example: built-up area, mainly compact high-rise; Urban forest and Lake. The modelling results show that during the wet season, the built-up area is under moderate heat stress during all day, while both urban forest and lake vary from moderate at night to strong heat stress during the sun-light hours. On the other hand, during the dry season, all environments present a similar curve, with UTCI varying from moderate to strong heat stress during sun-light hours and no heat stress in the night. The maximum difference between the built-up area and the urban park is 1.9 °C (UTCI) at 16hUTC. The analysis of the UTCI can provide valuable information to urban planners on how people will perceive the heat, on where to place new residential areas and how to plan new or recover existent parks in tropical cities.

Session Themes

Urban climate methods: Modelling

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Parametrizing the impact of heterogeneous urban canopies on local climate using nudging

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Abstract

A multi-layer urban canopy parameterization using a nudging approach has been developed and integrated into the mesoscale atmospheric model METRAS to improve the urban surface representation. The nudging approach has the advantages of simple implementation and reasonable model results, moreover, it is widely used as a data assimilation approach in global-scale models. One of the objectives of such a canopy parameterization using nudging is thus to prepare for its direct usage in the global-scale models with a typical resolution of 1 km so as to improve meteorological variables calculation for heterogeneous urban canopies.

In this work, the city Hamburg with heterogeneous surfaces was selected as the study area. Urban canopy information for Hamburg such as building height and building surface fraction (i.e., the ratio of the surface area occupied by buildings to the total plan area) were obtained from the 3D city model of Hamburg LoD1 (Level of Detail 1). Model simulations are made for summer 2020 with particularly focusing on the maximum urban heat island phenomena. Through modifying the existing nudging equation in METRAS, urban canopy effects on local climate such as reduction of mean wind speeds, enhanced aerodynamic turbulent fluxes as well as urban heat island phenomenon are represented.

Session Themes

Urban climate methods: Modelling

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Urban heat island observation from the fusion of connected vehicle and personal weather station measurements

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Abstract

Crowdsourced observations of temperature are now available in densely populated areas. In the field of urban climatology, personal weather stations have already shown their interest to observe the urban heat island. Considering that connected vehicles are ubiquitous in urban areas, we investigate the potential of measurements from on-board thermometers. The huge amount of temperatures from personal cars allows to reliable estimate the urban heat island at fine resolution. We also develop a geostatistical model which creates maps with the combination of personal weather station and connected vehicle temperatures. With this method, both datasources complement each other and we extract a good quality signal, close to the one obtained with Rennes and Dijon reference urban networks. This fusion of opportunistic data can be used to observe unexplored areas, detect the cooling effect of parks, evaluate the impact of meteorological conditions and the diversity of regional environments. It is a new opportunity to target critical areas and support urban planning decisions.

Session Themes

Urban climate methods: Urban climate informatics

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Quantification of road-traffic emission factors for ultrafine particles from multi-year particle number flux measurements using eddy covariance

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Abstract

Ultrafine aerosol particles (D_p < 100 nm, UFP) can enter the human body via the respiratory tract and cause acute and chronic adverse health effects. In cities, road traffic is the major source of ultrafine particles. The source strength of urban road traffic can be quantified using emission factors, which are an important input for numerical models calculating urban pollutant/particle dispersion. One way to calculate traffic emission factors is to combine turbulent particle number fluxes with traffic data in the source area of the flux measurements. Since the number of particle flux measurements in urban areas, especially for long-term measurements of size-classified particle fluxes, is currently still relatively small, only few comparative data are available.

In the present study, a 3-year data set of size-classified particle flux measurements from Berlin was used to calculate emission factors for the traffic fleet in the source area of the particle fluxes. Based on the size-classified flux measurements, emission factors for different particle fractions, e.g. < 30 nm, < 100 nm (UFP) as well as < 200 nm, can be calculated and compared with literature values. The emission factors are determined for individual years of investigation in order to be able to discuss annual variability and changes in the factors. The mean road-traffic emission factor for UFP was 2.25 ± 0.68 x 10^{14} veh^{-1} km^{-1}. The study finds robust results when using the methodology to calculate emission factors from eddy covariance data, which are comparable in magnitude to other sites reported in literature.

Session Themes

Urban climate processes: Urban air quality

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When simulations last too long and experts are out of reach – Alternative method to obtain first and simple quantification of the effectiveness of adaptation measures to heat

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Abstract

Urban green represents an important heat adaptation measure (AM) with regard to climate change. Against the background of limited human and financial resources in many cities, it is therefore important to quantify and evaluate the effectiveness of different AMs in order to prioritise appropriate AMs in urban neighbourhoods. Therefore, it is necessary to provide the responsible actors with adapted methods, e.g. indicators, for decision-making. This prerequisite has been insufficiently fulfilled so far (e.g. Barthesaghi Koc et al. 2018).

In the joint project 'HeatResilientCity', an indicator was therefore developed based on urban climate simulations (ENVI-met, Bruse 1999), which allows a first, simplified quantification of the effectiveness of AMs concerning heat. A bioclimatic index (UTCI; Universal Thermal Climate Index, Jendritzky et al. 2012) is used to assess the effectiveness of AMs. Both daytime and nighttime conditions are addressed, thus taking into account the fact that not all AMs are equally effective for all day times. Two different categories are implemented. The first one addresses the effectiveness of individual AMs on small areas of limited extent and the second one the quantification of the effect of roadside greenery.

The user is provided with a selection of predefined areas representing different adaptation measures, each of which is briefly described in a fact sheet. The associated UTCI values are stored in a database and thus enable a comparison of the thermal load of different example areas.

The indicator set is being developed in cooperation with practical partners from two cities in Germany (Erfurt and Dresden) with the aim of making the indicator set user-friendly.

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Session Themes

Urban climate policy: Planning and Governance

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Applying Local Climate Zone classification to study future land use impacts: Case study from Helsinki metropolitan area

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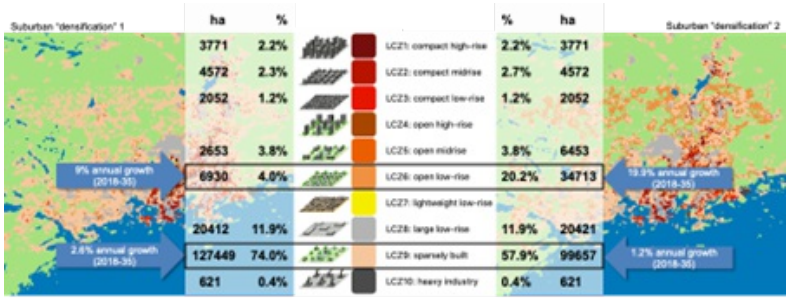
Abstract



Fiq. 1 Future urbanization scenarios for Helsinki metropolitan area by LCZ classification

Sustainable cities are formed by different combinations of design concepts, and in literature the best features of a sustainable city are under wide discussion. Climate change mitigation (CCM) and adaptation (CCA) need integrated approaches.

In our approach, we combined urbanization scenarios, simulated with the SLEUTH cellular automaton model, with microclimate scenarios by using the Local Climate Zones (LCZ). The model applies an advanced computational approach, which is based on spatial data, and it aims to be an important contribution to the field of urban studies because it firstly equips urban simulation with the capacity to assess the effects of climate change policy on exposure and vulnerability, in addition to mitigation components, and secondly has the form of a planning support system for inclusive co-design of urban futures. The theoretical base for this approach comes from agglomeration theory and spatial econometrics, in the general theoretical backdrop of complex adaptive systems.

When coupled with scenario simulation capabilities, (GIS) provide excellent tools for scientists and experts to analyze urban development, while decision makers and planners can use GIS-based end-product applications to support environmentally, socially and economically sustainable development and growth in urban areas. Our approach considers CCA and CCM inside broader urban spatio-temporal dynamics to enhance urban resilience.

Acknowledgements and funding

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Session Themes

Special Session: World Urban Database and Access Portal Tools (WUDAPT): World Urban Database and Access Portal Tools (WUDAPT)

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Landscape metrics in assessing how configuration of urban green spaces affect their cooling effect: a systematic review

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Abstract

The construction of urban green spaces (UGS) has long been proved an effective mitigation to urban heat island effect, and decades of studies have evaluated how the composition and configuration of UGS may influence their cooling. Derived from landscape ecology, landscape metrics have widely been used as quantitative indicators in assessing UGS configuration, i.e., shape complexity, fragmentation, connectivity, etc. However, such previous studies have accumulated controversial results, which cannot provide urban and landscape designers with holistic insights for future sustainable development. Thus, this study was intended to (1) review past studies that have used landscape metrics to evaluate how UGS's configuration may influence their cooling effects, and (2) synthesize and categorize frequently used metrics and these results from the perspective of research scale, research method, data source, climate zone, and the urban context these studies were conducted.

A total of 136 papers were identified by applying a systematic review procedure. A diverging definition of UGS has been identified, which are a land-use perspective (33, 24.3%) and a land-cover perspective (100, 73.5%), with another 3 (2.2%) integrating both. The shape of UGS has been most evaluated (97, 71.3%), among which 18 (13.2%) believed that UGS with a compact shape provides better cooling, while 23 (16.9%) held the opposite opinion. Among all reviewed studies, the most studies were conducted in Cfa (39, 28.7%) and Dwa (29, 21.3%) climate zones. 124 studies (91.2%) have used surface temperature as temperature indicator, while 9 (6.6%) have used air temperature and another 3 (2.2%) using both. Future studies are advised to provide clearer linkages between metrics and different levels of planning and design practice, i.e., UGS planning, UGS design, and planting design, by choosing proper data resolution and UGS classification scheme, as well as finding links between landscape metrics and other UGS configuration research methods.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Quantitative effect of green coverage changes within an E-W street canyon as a planning measure to enhance human thermal comfort in summer

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Abstract

Facing the combination of regional climate change and demographic change worldwide, a significant task of urban planning is represented by the development and application of methods to enhance human thermal comfort within urban quarters during severe summer days. Among various measures, urban green infrastructure is the most important issues to reduce urban heat. Though numerous studies have shown the promotion of urban green to mitigate the regionally predetermined heat stress on the local urban scale, systematic investigations of different urban green infrastructure are still lacking.

Comprehensive numerical simulations using ENVI-met V5.0.2 were carried out in an E-W street canyon considering the representative urban structure in Jeju in Republic of Korea on the heat wave day, 15 August 2020. The simulations consist of 10 types of combination of urban green infrastructures such as street trees, grass, façade and roof greening. The results of green scenarios were compared each other with the result of a bare condition. In order to avoid the effect of surroundings for the targeted 25 m x 45 m E-W street canyon, the simulation domain covers a horizontal area of 285 m x 215 m with 1 m resolution. An implemented full-forcing function plays a part in contributing to reliable simulations for the near-surface air temperature (Ta), mean radiant temperature (Tmrt) and physiologically equivalent temperature (PET). Averaged over targeted open area of the E-W street canyon for the 10 types of green scenarios resulted in the maximum reduction of mean ΔTa amount to 1.1 °C, mean ΔTmrt to 19.1 °C and ΔPET to 12.0 °C. Especially, the street trees showed the greatest effect on the reduction of Tmrt and human thermal comfort.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Spatio-temporal characterization of Surface Urban Heat Island (SUHI) and Green Infrastructure (GI): A case study of Delhi, India

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Abstract

The world is moving towards urban transition – rural areas losing their identity and amalgamating into near urban sectors, forming a vast urban center. This global population shift has various impacts on urban areas, including energy demand, deteriorating air and water quality, worsened thermal environment, etc. The study focuses on the notorious effect of urbanization, where rapid and unplanned urbanization of cities and concomitant reduction in vegetation result in raised temperature compared to non-urban areas, creating a phenomenon known as the ‘Urban Heat Island’ (UHI). The study focused on the surface UHI (SUHI); SUHI is the effect generated by skin temperature of the surface. SUHI thermal trend can be identified in the daytime and nighttime. An image analysis procedure based on a two-dimensional Gaussian fitting to describe the surface urban heat island (SUHI) is developed using Landsat data from the Year 2015 to 2020 on the MATLAB platform. This fitting provides spatial extent, critical hotspots location and magnitude of SUHI. SUHI parameters were extracted for the Area of Interest (AOI) by exploring temperature difference of the cells of the delineated Land Surface Temperature (LST) map, further the Landsat data has been used to delineate landscape pattern using Normalized Difference Vegetation Index (NDVI) on season wise. Critical zonation map of SUHI is overlaid with NDVI to analysis the possible relationship and suggesting mitigating measures using GI.

Session Themes

Urban climate methods: Observations

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First comparison of urban routine numerical weather predictions and large aperture scintillometry observations

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Abstract

Turbulent sensible heat fluxes (Q_H) can be derived from large aperture scintillometry (LAS) sensors. These instruments allow for larger source areas to be measured than traditional eddy-covariance techniques, similar in size to the grid-boxes of typical regional numerical weather prediction (NWP) models (O(1 km)). To evaluate NWP using LAS, horizontal and vertical resolution characteristics need to be considered to ensure variables are spatially (e.g., both within the inertial sub-layer) and temporally (e.g., samples versus averages) comparable. We introduce a methodology to undertake such comparisons for the first time in cities. The workflow is demonstrated for two days in densely built-up central London for the UK operational NWP model (Met Office 1.5 km UKV). Diagnostic output at both the surface and closest model level to the observation's effective measurement height (z_f) are compared. The dynamically changing observation source area (with wind direction, stability, etc.) is accounted for by changing the NWP grid-boxes included in the comparison, typically resulting in 4-8 grid-boxes being used to obtain fluxes. As LAS fluxes are averaged in both time and space, Q_H can be averaged for similar periods as the UKV's timestep (e.g., 1-min). However, modelled Q_H agrees better with longer observational averages (e.g., 10-min) as the model at this resolution is unable to explicitly represent higher frequency turbulent motions. The UKV lacks land-cover variability across adjacent grid-boxes, meaning small differences between weighted modelled surface Q_H and the grid-box positioned over the centre of the LAS path (largest at a 5% difference). Larger differences are seen between UKV surface Q_H and UKV Q_H from the model level closest to observation z_f, despite both being within the ISL. We conclude that using LAS-derived Q_H is beneficial for evaluating NWP models, becoming more beneficial as modelling goes to higher resolutions (where land-cover becomes more resolved).

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Urban climate methods: Modelling

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Pedestrians’ comfort as a priority for urban design: a case study in Milan (IT)

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Abstract

The COVID-19 pandemic has demonstrated the importance of outdoor public spaces for people. Since microclimate considerably impacts people, affecting their experience in outdoor spaces, additional attention should be paid to the climatic conditions of the urban space. For necessity or leisure, most people spend time walking outside every day; this activity demands particular attention from urban designers and municipalities, especially during exceptional conditions such as heat waves. Multidisciplinary approaches are needed to implement scientific knowledge into urban design: this can be done through innovative tools for practitioners and decision-makers to propose climate- and user-responsive outdoor spaces. This contribution draws attention to the importance of providing comfortable and safe paths for users, analysing sidewalks from the microclimatic perspective. Specifically, investigating solar exposure of users’ walking paths leads to the design phase, in which temporary and permanent solutions to shade pedestrians are proposed. The methodology is tested on a new development in Milan (IT), in collaboration with the industry partner. The pedestrian network is previously classified to prioritize the design intervention on the most used pedestrian paths. By overlaying solar exposure and spatial relations, valuable insights are obtained to define short- and long-term solutions to protect people from solar radiation-related risks. The changing direction of the sun rays contributes to flexibility and dynamism in outdoor spaces. Different scenarios are investigated, and the design proposals are evaluated based on the user experience. The research illustrates the outcome that can be obtained when users’ comfort is among the priorities of urban designers. The result is the application of a tool developed for both urban designers and municipalities, to implement microclimate information into the outdoor spaces design process.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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IoT-based microclimate sensing and analytics for urban street canyons in Singapore

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Abstract

This study focuses on the microclimatic conditions at different ambient surroundings and heights in the street canyon of densely-built residential areas in Singapore. Firstly, air temperature, relative humidity, wind speed and direction, and particular matters (PM 1, 2.5, and 10) were measured continuously for 9 months in a typical neighbourhood, consisting of both mid-rise and high-rise residential buildings. The urban climate in street canyons at different locations is visualized and compared. Secondly, the distribution of air temperature, wind speed/direction, and air pollutants in the studied area are analysed, to understand the impacts of greenery, building density, sky view factor, and residents' activities on the air temperature, wind speed, and air pollutants dispersion. The relationship between urban morphology parameters and microclimate conditions is analysed. Thirdly, based on collected data and analysis, recommendations are proposed to improve the thermal comfort and energy efficiency of residential buildings.

Session Themes

Urban climate methods: Observations

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COVID-19 lockdown-related effects of traffic reductions on size-resolved particle number fluxes in Berlin

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Abstract

The COVID-19 outbreak and the associated lockdowns ordered by many authorities resulted in a limitation in people's mobility and a worldwide reduction of carbon dioxide and pollutant emissions. This led to an enhancement in urban air quality, especially concerning NO_x. However, it is uncertain to which degree the decline in urban road traffic as a major source of urban particles influenced size-resolved particle number fluxes.
We analysed size-resolved particle fluxes measured in Berlin during the first German-wide COVID-19 lockdown period (16 March until 06 May 2020) in comparison to a reference period from the preceding years 2017 - 2019. The analysis of the footprint locations and meteorological conditions concerning turbulent mixing and atmospheric stability demonstrated similar conditions so that the effect of reductions in traffic intensity can be estimated.
The study finds a statistically significant reduction in median ultrafine particle number fluxes (F_{UFP}) from 8.78×10^7 m^{-2} s^{-1} during the reference to 5.44×10^7 m^{-2} s^{-1} during the lockdown period (reduction of -38 %). The reduction was evident in every single size bin of the size spectrum (10 nm < D_p < 200 nm), while traffic intensity declined by around -35 % in the flux footprint area. During the lockdown period, a shift in the frequency distribution of F_{UFP} from stronger emission fluxes to weaker emission and deposition fluxes becomes apparent, resulting in a higher frequency of particle deposition (8.9 %) in comparison to the reference period (5.7 %). The size-resolved analysis demonstrates that net deposition of ultrafine particles on the diurnal cycle occurs only during nighttime under low-traffic conditions whereas accumulation mode particles are also deposited during daytime.

Session Themes

Special Session: COVID/pandemic lock-down: Impact of COVID/pandemic lock-down measures on Urban Climate, Air Quality, and Human Life

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Urban micro-climate controls on intra-urban variations in vegetation growing season length and timing in a semi-arid city

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Abstract

Urban vegetation is growing in importance as cities use ‘green infrastructure’ to mitigate the impacts of climate change, reduce extreme heat, and improve human health and comfort. However, due to the extreme heterogeneity of city landscapes, urban vegetation experiences a diverse range of environmental conditions, potentially leading to differences in growing season timing and length within cities. Here, we investigate physical drivers of urban vegetation phenology and timing in a semi-arid city (Denver, CO, USA) using four years (2018-2021) of remotely sensed vegetation, surface temperature, and land cover datasets. Within the metropolitan region study area, satellite-based vegetation index measurements (NDVI) indicate growing season length is variable on sub-neighborhood spatial scales. Preliminary results suggest this is largely due to differences in the timing of fall senescence, as opposed to early season growth. Areas with substantial fractions of irrigated land cover and greater soil moisture tend to remain greener longer, while un-irrigated and warmer areas are correlated with an earlier end to the growing season. These results contrast with findings from other cities in environments that are not water-limited, where surface and air temperature are the dominant environmental control on phenological timing. Urban vegetation growing season dynamics and temperature-vegetation feedbacks specific to semi-arid regions have implications for water, heat, and vegetation management strategies to maximize ecosystem services in water-limited environments.

Session Themes

Integrated assessments of urban climate : Inter-scale interaction of urban phenomena and climate

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Thermal Comfort Characterization of Compact Mid-rise Local Climate Zone and its Morphological Variables Correlation in the city of Hyderabad, India

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Abstract

India is urbanizing at a rapid pace. Presently, the urban population is 460 million, accounting for 33.6% of the total population. By 2050, additional 404 million urban dwellers will be added. Hyderabad is the fourth most populous city in India and has transformed significantly since the advent of the Information Technology industry in the early 2000s. Urban Morphology has a significant impact on the thermal stress of a neighbourhood. LCZ classification system allows for categorizing different morphologies in a standardized fashion. Compact Mid-rise is the predominant local climate zone (LCZ) in urban settlements in India. It covers about 31.5 per cent of built cover classes in Hyderabad. This climate zone houses primarily residential and small-medium enterprises. This typology is driven by the local developmental controls and economics of scale. This paper's methodology involves identifying multiple Compact Midrise neighbourhoods through the LCZ classification. Then the thermal environment of Compact Mid-rise LCZ neighbourhoods was simulated using ENVI-met numerical simulation software and validated with onsite data. The next step involves extraction of morphological parameters like the Sky view factor, Building and Green Surface fractions, Pervious and Impervious surface fractions, Floor Area ratio etc. Physiological Equivalent Temperature (PET) is adopted to assess the thermal environment. Subsequently, morphological variables' sensitivity and comfort index correlation were generated. Empirical regression models will be built correlating PET with morphological indicators. This analysis will highlight the sensitivities and impact of morphological parameters on comfort indices specific to Compact Mid-rise LCZ. This understanding will be critical to informing the urban planning domain to bridge the gap with urban climate at a neighbourhood level.

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Biometeorology & health: Urban microclimate and comfort

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Causal analysis of spatial patterns of urban heatwaves among U.S. cities

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Abstract

Extreme heatwaves are projected to be more frequent and devastating under global climate changes, with significant implications to health risks and socio-economic sustainability, especially in developing and rapidly urbanizing countries. Nevertheless, the causal interactions between heatwave events and background climate, as well as their spatial patterns, remain obscure up to date. In this study, we used an advanced causal inference algorithm, viz. the convergent cross-mapping (CCM), to analyze the spatial patterns of selected historic mega-heatwaves in the U.S. cities. The results show that mega-cities, such as New York, Los Angeles, or Chicago metropolitans, serve as the *pacemakers* of extreme heatwaves, with high causal influence and susceptibility, which is likely due to the concentrated anthropogenic stressors. In addition, it is found that the connectivity and propagation of urban heatwaves across different areas are strongly regulated by the presence of regional climate zones with convergent atmospheric flow and transport such as the Ohio Valley. The spatial patterns of the *causal network* of U.S. urban heatwaves involve complex interplay of anthropogenic activities and background climatic conditions. The data-driven causal analysis presented in this study sheds new lights on unraveling the underlying dynamics of heatwave events and will help to improve the predicative capacity of climatic extremes in general.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

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Characterization of sea breeze cooling in selected Australian cities

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Abstract

The sea breeze is a common phenomenon in coastal cities, but its cooling effect has not been well investigated. In this study, the Sea Breeze Cooling Capacity (SBCC) was defined to quantitatively characterize temporal and spatial patterns of sea breeze cooling and their influencing factors at different spatial scales based on observations for selected Australian cities.

Inside the Adelaide Central Business District (CBD), the SBCC ranges from 733.9 to 858.7 °C·h per season (or from 19.0 to 22.2 °C·h per event) across observation sites. The spatial variation of SBCC can primarily be explained by Frontal Area Index (FAI), Terrain Ruggedness Index (TRI), distance from the coast, and temperature prior to the sea breeze onset. Specifically, SBCC is negatively correlated with FAI and positively correlated with TRI. Over the metropolitan Adelaide, SBCC decreases at a rate of 0.7 °C·h (an average sea breeze day) and 0.9 °C·h (a hot sea breeze day) per kilometer away from the coast, leading to smaller SBCC over the metropolitan Adelaide in hot sea breeze days than in other sea breeze days. . This can be explained by a higher frequency of synoptic systems with directional flows from east or south-east during hot sea breeze days in Adelaide.

Significant differences in SBCC are found in Perth, Adelaide, and Melbourne, with Perth of 1195.1 °C·h per season, Adelaide of 935.0 °C·h, and Melbourne of 630.4 °C·h The difference can be attributed to the frequency of anti-cyclone occurrence. These findings provide important implications for urban planning, public health and energy consumption in coastal cities.

Session Themes

Urban climate processes: Extreme weather and disasters in the urban environment

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Do we need to apply maintenance to globe thermometers in outdoor use?

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Abstract

Globe thermometers have been widely used to evaluate mean radiant temperature (MRT) and wet-bulb globe temperature (WBGT), which are applied to assess human thermal perception and heat stroke risk. In long-term outdoor observations, accumulation of dirt on the surface of the globe thermometer may affect the measurement accuracy due to changes its surface albedo. Thus, maintenance of the globe thermometer is considered necessary. However, neither the necessity nor suitable maintenance protocols are clear. To investigate effect of maintenance procedures on the measurement accuracy of globe thermometers, a total one month of outdoor observation was conducted in a grass covered site and a school playground covered with bare soil. The main difference between the two observation sites was the state of dust in the atmosphere. Globe thermometers were more likely to get dirty because more dust was scattered on a school playground than other site. In this observation, four globe thermometers with 150 mm diameters were used and the following maintenance methods were adopted for each of them: wiped with a wet cloth every day, wiped with a wet cloth once a week, wiped with a dry cloth once a week, and no maintenance. In addition, the surfaces of all globe thermometers were photographed daily to check the degree of dirt accumulation of them. The results showed that the difference in maintenance procedures were not attributed to the measurement accuracy of the globe thermometers regardless of the atmospheric conditions. Besides, we confirmed the surface dirt of globe thermometers were naturally maintained by rain. In Japan, rainfall is observed at least once a month at a high probability, and the results of this study support no maintenance is required for globe thermometers.

Session Themes

Urban climate methods: Observations

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Urban morphometrics and socio-physical livability in Slum Rehabilitation Housing; a case of Mumbai, India

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Abstract

Rapid urbanization in India, and population influx due to livelihood prospective has led to the pressing urban distress, especially in low-income neighbourhoods. In Mumbai, the vertical, hyper dense, mid to high-rise slum rehabilitation compounds are characterized by the loss of socio-physical livability, and environmental vulnerability due to compromised design considerations at the neighbourhood, building and interior levels respectively. The sole focus of maximizing the housing density, ignoring the neighbourhood livability resulted in rebound phenomenon, hotspot for crimes and energy crisis. Therefore, the aim of the research is to optimize urban morphometrics for the Slum Rehabilitation Housing(SRH) in the context of Mumbai, India, while satisfying the threshold housing density (650DU/Ha). An integrated design framework, with the built environment indicators and relevant biophilic strategies were developed to assess an existing SRH compound (Natwar parekh compound, Govandi, Mumbai) as a base case scenario. Further, multiple design iterations related to urban morphometrics parameters were optimized and validated with respect to the desired physical and social livability, facilitating the built environment indicators at the neighbourhood and building level. With an aim to reduce verticality, the well-ventilated cluster of 5 and 7 storied structure, oriented along the prevailing wind from west, with its longer axis in the N-S with an aspect ratio ranging from 2 to 3, were iterated with multiple interlinked courtyards and mutually shaded open spaces. The iteration with 34% building footprint, aspect ratio of 3 and housing density of 675 DU/Ha, resulted in a reduction of 2-3oC in MRT at the most critical period of 2 pm in May. Also, the optimized morphometrics at the neighbourhood level along with volumetric variability enhanced the daylight potential and adaptive comfort hours by 82%, while the integrated open spaces at neighbourhood and building level to foster cohesive, vibrant character epitomizing a traditional Indian neighbourhood.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Different spaces for outdoor thermal comfort during summer in a coastal city : A comparative study

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Abstract

Outdoor thermal comfort（OTC） is an important factor in increasing the use of public spaces and enhancing public health. OTC studies for different climate zones and cities have been widely conducted, but there is a lack of comparisons of the variability of different types of spaces within the same region. In this study, Dalian, China, was selected to conduct on-site investigation of thermal comfort in three typical urban areas—campus, park, and business street during summer. Outdoor thermal benchmarks were determined by meteorological measurements and questionnaires, using the universal thermal climate index (UTCI). The results showed that: (1) T_g and T_a were the main factors affecting the OTC in Dalian in summer, with T_g having a greater influence on the park and business street and T_a on the campus. (2) The comfort of shaded spaces was significantly higher than that of open sites. (3) The NUTCIs of the campus, park, business street were 23.8 °C, 25.3 °C, and 27.9 °C, respectively, and the NUTCIRs were 22.4 - 25.2 °C, 22.3 - 28.2 °C, and 25.0 - 30.9 °C. (4) TAR was slightly higher than UTCIR for the three areas, but the differences were not significant (TAR_{Campus} = 20.3 - 26.8 °C, TAR_{Park} = 23.8-30.0 °C, and $TAR_{Business\ Street}$ = 25.8 - 31.7 °C). The results of the study provide a good reference for determining outdoor thermal environment improvement strategies in coastal cities.

Session Themes

Integrated assessments of urban climate : Urban climate and climate change

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Toward a Local Climate Zone-based drag and mixing length parametrization for the urban environment

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Abstract

Future meteorological and numerical weather prediction models should be able to operate at the hectometer scale in cities with heterogeneous morphology and high-rise buildings. To this end, urban climate models have to be coupled at multiple levels with atmospheric models. The buildings effects on the flow can be parametrized via the imposition of vertical profiles of the building drag coefficient and the urban mixing length. Building-resolving micro-scale simulations can be employed to derive these quantities.

In the present contribution, 1-m resolution micro-scale large-eddy simulations of eleven Local Climate Zone (LCZ) based urban morphologies with various building plan and frontal density are used to provide sectional drag coefficient and mixing length reference vertical profiles for the urban environment. The simulations are performed using the MesoNH-IBM meteorological research model which represents explicitly the obstacles with the Immersed Boundary Method and accounts for the impact of the large-scale turbulence structures on the urban canopy thanks to dynamical downscaling and embedded numerical domains using the grid nesting method. The results show that the velocity profile is generally not exponential and the mixing length is not constant in the urban canopy. This is contrary to traditional assumptions but in agreement with recent research.

The sectional drag and mixing length profiles are then used to propose a new LCZ-based parametrization for the wind dynamics in the urban environment when using the Meso-NH model at the hectometer scale. The results for 100-m resolution meso-scale simulations show that the proposed parametrization is more efficient than the current one, consisting in a constant drag coefficient and no specific modification of the turbulent mixing length scale in the urban environment.

These results open new perspectives to better parametrize the dynamic effects of real urban areas at the meso-scale.

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Urban climate methods: Modelling

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Using machine learning for fine resolution hourly thermal environment mapping

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Abstract

The limited coverage of the observation network and the complex urban morphology make it difficult to map the fine thermal environment at the surface level within and around cities using conventional methods, but artificial intelligence technologies offer the possibility of infilling urban climate observation networks. Thus, this study developed techniques and methods for hourly thermal environment mapping over multi-year warm seasons using machine learning (ML) algorithms and meteorological and landscape data, and applied them to two spatial scales at 1-km and 100-m resolution respectively. Random forest algorithm was employed for the hourly thermal environment mapping, including air temperature (Ta) and relative humidity (RHU). Guangdong Province was selected at the regional scale, while Hong Kong was selected at the city scale. By comparing the observed and estimated values of the test sample set, the hourly Ta maps exhibited good accuracy from 2008 to 2019, with mean R^2, root mean square error (RMSE) and mean absolute error (MAE) values of 0.80, 1.48℃ and 1.09℃, respectively, compared to 0.87, 1.12°C and 0.82°C at the city scale. For RHU, the three metrics at the city scale were 0.80, 5.38% and 3.86%, respectively. The drivers' importance assessment shows that the meteorological factor most contributed to both indicators and that they were the most important drivers to each other. Simultaneously, landscape factors also played a non-negligible role in enhancing the spatial details of the temperature mapping. Further analysis revealed that nighttime Ta in the metropolitan core areas tended to decline more slowly than in the urban fringe, which related to the local-climate-zone-based urban morphology. Overall, this study demonstrates the feasibility of using ML to infill urban climate networks, and provides novel, valuable and reliable datasets for thermal environment mapping. It contributes to the understanding and analysis of urban climate and urban scale climate change.

Session Themes

Urban climate methods: Urban climate informatics

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A wind tunnel study of turbulence flows over real urban surface with statistical scale analysis

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Abstract

Roughness sublayer (RSL) and inertial sublayer (ISL) in the atmospheric surface layer (ASL) over roughness elements exhibit dissimilar dynamics and turbulence structures. In this study, wind tunnel experiments are carried out to measure the ASL flows over the reduced-scale model of real urban morphology. Quadrant and frequency analyses are used to examine the ASL momentum transport and how the processes are influenced by different motion scales. The downtown Kowloon Peninsula, Hong Kong is fabricated by 3D-printing that is adopted as the model. Notable variations of mean wind speed u, fluctuating streamwise u" and vertical w" velocities together with vertical momentum flux u"w" exist in the ISL and RSL. With increasing motion scales, the efficiency of momentum transfer increases in the RSL top and the ISL. The transfer efficiency is peaked in the ISL regardless of the strength of motions. Moreover, the strengthening motion scales result in an increasing and decreasing contributions from ejection Q2 and sweep Q4, respectively, to momentum transport. Whereas, the phenomenon is opposite in the ISL. Additionally, the contribution from eddies in the frequency range of 0.1 Hz to 10 Hz is least then increases thereafter with increasing frequency in the RSL. On the other hand, the contribution increases monotonically with increasing frequency in the ISL. It is thus suggested that large turbulence scales dominate aged air removal of urban areas.

Session Themes

Urban climate processes: Boundary layer and urban canopy layer processes

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Climate Adaptation in the Street: a scaleable climate responsive shading system for outdoor thermal comfort

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Abstract

Urban climates are facing extreme and extended periods of high temperatures due to the interacting pressures of climate change and the urban heat island effect (Urban Climate Change Research Network, 2018). This affects energy consumption, urban biodiversity, human health, and overall liveability of cities (Nowak, 2010; Santamouris, 2021). Microclimate mitigation measures are needed at multiple scales within the urban landscape, from street scale design interventions to city scale policy changes. Small scale design interventions, while effectual only at the microscale can offer significant adaptive capacity to the city at large if strategically located where urban microclimate conditions and social needs intersect. The provision of shading in particular can significantly improve microclimate conditions at the small scale (Erell et al., 2011; Latini et al., n.d.; Sharmin & Steemers, 2018). Shade related design options such as building geometry require implementation pre-build; or shade trees require significant time to be optimally effective. Of the artificial solar shades, lightweight canopies can offer a flexible, easily deployed, economical mitigation approach, providing direct relief to those using outdoor urban spaces as well as helping to keep the local urban surfaces cooler improving both indoor and outdoor thermal comfort. However, the standard shade canopy is a universal approach to hyperlocal conditions potentially leading to reduced daylighting in surrounding buildings, reduced ventilation in street canyons and overshading as conditions change across the day, and throughout the year. This project proposes the design of a climate responsive shading system, utilising computational design and the ability for interaction to produce a locally adapted shade response while maintaining the lightweight, flexible and economic characteristics of a traditional shade canopy thus maintaining the ability for up-scaling. In particular, the layered responses of; canopy form derived from sun vectors, textile properties of openness factor and retroreflective characteristics, and ability for ‘real-time’ interaction are explored.

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Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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A comparison of turbulent flows over idealized urban and vegetation canopy

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Abstract

Atmospheric flows in the inertial sublayer (ISL) and the roughness sublayer (RSL) are largely affected by the urban and vegetation canopies beneath. In this study, the turbulent flows over idealized urban and vegetation canopies are modeled by wind tunnel experiments. The effect of aerodynamic resistance on the RSL and ISL turbulence structure is contrasted. Vertical profiles of velocity and turbulence statistics are sampled by hot-wire anemometry (HWA) to examine the dynamics over different configurations of urban and vegetation canopies so as to elucidate the transport processes. The influence of aerodynamic resistance on the turbulence structure is evaluated by quadrant analyses. It is shown that extreme events (ejection Q2 and sweep Q4) augment RSL transport. The outward interaction Q1 and inward interaction Q3 in RSL occur more frequently than their ISL counterparts. On the contrary, Q2 and Q4 contribute more to RSL momentum flux compared with ISL one. Quadrant hole analysis examines the relative importance of Q2 and Q4. The results show that Q2 (Q4) occurs more (less) frequently in RSL, but contributes less (more). The results demonstrate the dissimilar transport mechanism between ISL and RSL over canopies. Further to the quadrant analysis, a series of frequency analysis is carried out to investigate how turbulence eddies with different scales contribute to the transport processes.

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Urban climate processes: Boundary layer and urban canopy layer processes

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100m urban simulations over Singapore using uSINGV

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Abstract

With the advancement in computational resources, the numerical weather prediction modeling community has responded with models that use progressively higher resolutions and more complex physics schemes. It is now possible to run a very high resolution (100m) atmospheric mesoscale model coupled with urban schemes. In this study, we simulate a domain over Singapore with 100m horizontal resolution using the uSINGV model and compare the results with the model using a 300m domain. For the 100m simulations, the urban morphological parameters are calculated from the building height and footprints dataset. Moreover, an updated land use/ land cover is created and incorporated within the model. The simulations are run for two clear days (24 Jun 2013 and 29 Jan 2014), and the results suggest good performance in capturing the general characteristics of mean 1.5m air temperature and humidity. The added benefit of the 100m domain is found in resolving the sharp temperature and specific humidity gradients present within the city. The 100m simulations performed across an entire city have the potential to provide detailed neighborhood information needed for city-specific meteorological forecasts.

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Analyzing driving factors of the intensity and extent of surface urban heat island: a case study of major Chinese cities

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Abstract

Surface urban heat island (SUHI), which refers to higher land surface temperature (LST) in urban areas than in rural counterparts, affects energy consumption and human health. An improved understanding of SUHI is essential for building sustainable cities and a comfortable living environment. Due to free access and wall-to-wall coverage of satellite products, the LST-based SUHI drew rising attention to monitoring the thermal environment in recent decades. Most studies focused on the urban-rural temperature difference, i.e., SUHI intensity (SUHII), while recent studies paid more attention to the actual influencing area of SUHI, i.e., SUHI extent (SUHIE). However, the driving factors of both SUHI indicators remain less explored. Based on local climate zone (LCZ) data and MODIS LST product of major Chinese cities, this study aims to explore the influencing factors of SUHII and SUHIE during daytime and nighttime of winter and summer from the perspectives of background climate, socioeconomic condition and urban morphology. The results show that the dominant driving factors of SUHII and SUHIE are significantly different. The major influencing factor of SUHII is meteorological factors, while socioeconomic factors for SUHIE. Wind speed and relative humidity affect SUHII the most, and gross domestic product and industrial structure are the dominant influencing factors of SUHIE. From an urban morphology perspective, LCZ 1 contributes to the increase of SUHII and expansion of SUHIE, regardless of day/night or winter/summer. Besides, the impact of background climate on SUHI presents more significant seasonality compared to socioeconomic conditions and urban morphology. An in-depth understanding of the mechanism behind SUHII and SUHIE helps city planners, architects and government officials track urban heat from perspectives of intensity and extent.

Keywords: surface urban heat island (SUHI), driving factor, local climate zone, planning strategy

Session Themes

Urban climate methods: Observations

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Extensive validation of SOLWEIG for regional-scale thermal exposure mapping in Phoenix, Arizona, USA

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Abstract

High-resolution mean radiant temperature (Tmrt) maps provide important baseline information for thermal exposure research in the face of urban overheating. This study validated 1-m resolution Tmrt estimates from the solar and longwave environmental irradiance geometry (SOLWEIG) model for extreme heat conditions in the hot, dry Phoenix metropolitan area. The model domain's Digital Surface Models were generated using a high resolution LiDAR point cloud. Hourly Tmrt was simulated for hot summer days between 2016 and 2019 using local weather data as forcing. Mobile six-directional radiative flux measurements were obtained with the human-biometeorological MaRTy cart at 60 sites between 07:00h and 21:00h (773 observations) to validate the model for various urban forms in Tempe Downtown and a public park: sun-exposed locations, tree-shaded locations, and sites in urban canyons. Air temperature peaked above 40°C during observation days, and Tmrt peaked at 71°C between 14:00h and 16:00h. The model showed good agreement with an RMSE of 6.43°C for exposed sites, 5.43°C for trees, and 4.38°C in urban canyons. The model overestimated Tmrt in most cases. At mid-morning, noon, and peak air temperature, Tmrt was underestimated for building canyons and exposed sites and overestimated for tree-shaded sites. Differences in observed and simulated tree shade were mainly due to the LiDAR point density for tree crowns. After validation, the model was used to simulate a typical summer day (July 12, 2012) for regional-scale thermal exposure and shade mapping to inform the City of Phoenix's Cool Corridor program.

Session Themes

Urban climate methods: Modelling

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Climate Risk Vulnerability Assessment in Indian Himalayas

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Abstract

India is highly vulnerable to natural disasters. According to the global ThinkHazard database, India ranks “High” in almost every natural hazard indicator, including floods (coastal, urban, and river), landslides, cyclones, water scarcity, extreme heat, and wildfire. Climate change is expected to exacerbate these risks and have severe adverse impacts on human development, economic growth, and ecological resources. India was the seventh most climate-affected country in 2019, according to the Global Climate Risk Index (CRI) 2021.

Indian Himalayan region in particular are much more susceptible to climate change related risks. Ecological resources such as forests are already under stress from rising temperatures and changes in precipitation patterns, which will further increase as average temperatures in India are expected to rise by around 2 degrees C under a high emission scenario (RCP2.5) in the 2040-2059 timeframe. Indian Himalayas are facing a continuous cycle of extreme heat, landslides, cloudbursts, and flash floods. More extreme and erratic patterns of temperature and rainfall have increased the frequency and intensity of climatic events, such as riverine and flash floods, drought, avalanche, cloud bursts, landslides, and forest fires. Thus, there arises an urgent need to build resilience against future climate related risks.

This study aims to contribute in developing resilience against climate risks in Indian Himalayas through assessing climate risk vulnerability of an urban area located in Himalayas. The assessment is carried out in following three steps:

• Hazard Assessment: Various hazards present in the region such as Urban Heat, Floods, landslides etc. are analysed to identify the hotspots.
• Vulnerability Assessment: Sensitivity and Adaptive Capacity of the region with respect to identified hazards are estimated.
• Risk Assessment: Risks pertaining to each key sector is quantified through exposure, sensitivity and adaptive capacity estimated in previous steps.

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Integrated assessments of urban climate : Urban climate vulnerability in developing countries

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The relationship between Local Climate Zone (LCZ), surface temperature (Ts) and air temperature (Ta). A case study in Quito City

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Abstract

The change in the microclimate in cities due to the accelerated growth of urbanization has as a consequence the presence of ICU, due to urban geometry, surface coverage, thermal properties, and metabolism; Quito city has presented an accelerated growth in the last 30 years; therefore, it presents changes in the urban microclimate. This research aims to know the relationship of the LCZ, surface temperature, and air temperature in the City of Quito - Ecuador, to do so divide the research into three thematic axes; axis 1, Quito City, analyzes population growth, urban morphology and NDVI from the year 1977 - 2019, with remote sensing and SAGA GIS software; axis 2, Urban form and LCZ, the LCZ classification is applied in Quito through SAGA GIS with the Local Climate Zone Classification plugin and it is validated with a confusion matrix; the urban geometry is analyzed with UMEP – Urban Geometry - SVF, thus obtaining an SVF raster map, aspect ratio; with the thrjees plugin in QGIS the elements of the urban canyon are identified; axis 3, Urban Climate, analyzes surface temperature (Ts), air temperature (Ta), albedo and anthropogenic heat; to identify the LCZ variable, the most representative typologies LCZ 3, B, D, 2, 8 were selected, air temperature daloguers were placed in them, Landsat 8 satellite images were taken for the Ts variable; Once the measurements of the three variables LCZ, Ts and Ta are obtained, the correlation with geostatistics is applied, obtaining as a result, LCZ and Ts moderately negative connections, LCZ and Ta moderately negative connections; Ta and Ts strong positive connections; In addition, a difference of 1.5° to 2.8° between Ta and Ts is confirmed.

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Urban climate processes: Boundary layer and urban canopy layer processes

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The synergy of urban-met observation and citizen science participations in revealing the 4-dimensional heat heterogeneity in urban environment

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Abstract

In the digital era with internet of things (IoT), machine learning and smart cities applications, the low-cost environmental sensors and urban meteorological observation stations become easily accessible and replicable by the public authorities and educators. In Hong Kong, the Community Weather Information Network (Co-WIN) established since 2007 offers a large set of weather data with more than 100 conventional-typed automatic weather stations covering every district of the territory, and with the STEM and citizen science initiatives in recent years, comprehensive workshop programs were offered to local schools in collaboration with The Hong Kong Observatory.

By providing opportunities for students to DIY (do it yourself) their own low-cost weather sensors with programming, product design (i.e. 3D CAD), instrumental calibration, local fieldworks and GIS analyze techniques, the integrated education program across the institutions can help to foster the advancement in ‘down-to-earth’ science education. Meanwhile, fieldworks at school campus can serves as a testing ground for the understanding of heat heterogeneity with height and environmental differences, which the data collected by teenage and citizens during the campaign can help to provide a higher spatial-temporal meteorological measurement coverage in microclimate heterogeneity over urban environment. The results had demonstrated the schools-universities collaboration in measurement campaign can be a cost-effective and useful resource for supplementing the microclimate study in Hong Kong.

Keywords:
Urban built environment; Vertical profile; Thermal comfort; Citizen science; Community weather monitoring network; Smart campus

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Urban climate methods: Observations

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Evaluation of the microscale climate model PALM using professional and crowdsourced weather data fora heatwave period in August 2020 in Bochum

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Abstract

In summer and during heat events the urban heat island can negatively impact public health in urban areas. In the context of climate change, climate adaptation, therefore, receives more attention in urban planning. Microscale urban climate modelling can identify risks areas and evaluate adaptation strategies. At the same evaluating the model results with observational data is essential. This study uses the urban climate model PALM and its PALM-4U components to model a heat day in Bochum in western Germany with anticyclonic atmospheric conditions. Boundary conditions for the PALM simulation are obtained from the operational weather model COSMO-D2 by the German Weather Service. The model results are evaluated with climate data from two professional weather stations and air temperature data from citizen weather stations (CWS). A quality control procedure is applied to the crowdsourced data prior to evaluation. Urban-rural air temperature differences are represented by the model. The comparison between the model and the crowdsourced air temperature data reveals a good model performance with a high coefficient of determination and an RMSE around 2 K. Model accuracy shows a temporal pattern and night-time air temperatures on the second night are underestimated by the model, likely due to unresolved cloud cover in the model. No difference in model accuracy between surface types was found. The crowdsourced air temperature data proved valuable for model evaluation due to the high number of stations within urban areas. Nevertheless, weaknesses related to data quality such as radiation errors must be considered during model evaluation and only the information derived from multiple stations is suitable for model evaluation. The procedure presented here can easily be transferred to planning processes as the model and the crowdsourced air temperature data are freely available. This can help to make informed decisions for climate adaptation in urban areas.

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LARG-EDDY SIMULATION OF THE POLLUTANT DISTRIBUTIONS IN DIFFERENT TRAFFIC SCENARIOS CASE STUDY: A PLANNED CITY BOULEVARD IN HELSINKI

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Abstract

This study aims at understanding the high-resolution spatial and temporal variability of air quality in a planned city boulevard in Helsinki in different traffic flow scenarios. A large-eddy simulation (LES) model PALM with a detailed aerosol module (SALSA) will be employed to capture the complex interactions between the turbulent flow field and aerosol dynamic processes over a highly detailed representation of the urban domain. All simulations will be conducted over three domains including a nested child domain, a parent, and a root domain with a grid resolution of 1 m (Fig.1), 3 m, and 9 m, for the child, parent and root domains, respectively. Within the child domain, detailed city boulevard layouts will be used to simulate the aerosol processes by applying SALSA. Therefore, the model will be run for two representative days, which were determined as the most pollutant days during the winter 2021 for the morning rush hours (7_9 am) with varying traffic scenarios. The simulations results will be used to identify the most optimal urban planning choice including traffic scenarios for creating the best air quality in the planned city boulevard in Helsinki. We expect the traffic flow scenarios will have some impacts on local air quality, for instance the free-flow traffic will reduce the concentration in pedestrian level due to more turbulence in the street canyon which resulting more dispersion, whereas the congested-flow traffic increased the concentrations. On the other hand, in senaroius that vehicles can move faster, the concentration in both pedestrian level and local area will reduce. The outputs of this study could provide predictions about future air quality and traffic flows in the new city plan to urban planners and decision makers in order to improve the local air quality.

Key words: LES, ventilation, pollutant dispersion, urban planning, air quality

Session Themes

Special Session: High-resolution future climate projections for cities: The state-of-the-art and undelaying challenges

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Quantifying Personal Thermal Exposures for Diverse Populations and Climate Contexts Across Space and Time

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Abstract

Hot weather leads to an increased number of deaths and illnesses and loss of productivity. Fine-scale personal heat exposure (PHE) information can prevent or minimize these issues. However, current methods do not simultaneously account for the intensity, frequency, and duration of thermal exposures, nor do they include inter-individual factors that modify the physiological response and sensitivity to heat-related illnesses. This study aims to illustrate the new advances that can be achieved if new methodologies to quantify PHE based on thermal load calculations, where high thermal loads can lead to heat strain over time, and thus increase body core temperature. A human-environment heat exchange model is applied at the whole-body scale to demonstrate time-varying PHE and heat stress within different climatic contexts, while the inherent sensitivity for differences in body morphology and acclimatization status is considered. To show the differences in required and possible evaporative heat losses that can lead to dangerous thermal conditions, three personal profiles (middle-aged male and female, and female above 65 years), hourly data from the warm season for 3 climates (Phoenix, Miami, and New York), and 1-minute Phoenix microclimate data are used as model input. Results reveal critical details overlooked by using incomplete environmental data to evaluate PHE and by assuming that physiology and activities between people are equivalent. Moreover, results display that different "types" of heat (e.g., humid hot, dry hot) across hot climates do not elicit the same thermal response from the body. To overcome these difficulties moving forward, we outline criteria for providing reliable and inclusive PHE evaluations from physiological-based methods and discuss their implications to avoid misclassifications of health impacts within groups of concern and thus improve heat adaptation strategies. This work shows the value of moving away from a "one-size-fits-all" thermal index to a "fit-for-purpose" approach to estimate and predict PHE.

Session Themes

Biometeorology & health: Methods, applications, and translational research

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Human-biometeorologically adapted routing for optimizing leisure behavior and planning processes

Prof. Dr. Sascha Henninger, M.Sc. Lena Albert
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Abstract

The aim of the project is to identify trails that are as climatic, air-hygienic and healthy as possible - regarding the ozone formation potential. An isoprenoid-register and tree genus cluster in sense of a “traffic light system” will be created, which can be used for different locations. For this purpose an application should be programmed at the end of the project, which is applicable as a "climate isoprenoid navigation system“ for users. This app will show an idealized trail during autochthonous weather conditions - regardless of the location, supported by mathematical optimization. These optimizations will be able to bypass route sections, alternative routes are shown, which based on the length of the actual route and including the shortest possible detours.

The focus of this review is on the group of isoprenoids, precursors of ground-level ozone, emitted by various trees in different concentration, and forest areas, where a high potential of isoprenoid formation can be found or where the ozone formation potential is correspondingly increased. While many benefits emanate from green infrastructure, plants can also have adverse effects on health, especially during autochthonous weather conditions, when people visit green spaces for recreation.

This project is integrated into the joint project "Ageing Smart – Räume intelligent gestalten". The project is funded by the Carl Zeiss Foundation. The aim of the overall project is to develop a data-based decision support system that assists public actors in their planning processes. In addition to the recommendations for users in terms of the navigation app, recommendations for action and planning are given to the planning and decision-makers in order to indicate how new planning or new planting makes it possible to deal with health problems caused by green plants and could be avoided.

Session Themes

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Quantifying the urban carbon dioxide fluxes at high spatio-temporal resolution

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Abstract

A multi-layered and validated high-resolution approach is presented to quantify the spatio-temporal variability of net CO_2 flux at the whole city scale. Our approach maps the main anthropogenic and biological components of the carbon cycle in the urban system, such as traffic, building energy consumption, human respiration, and net ecosystem exchange of CO_2. (NEE) to yield the hourly gridded net CO_2 flux with 100 meters of resolution. The model utilizes proxy spatial sources, traffic, meteorological and remote sensing data, and Artificial Intelligence (Machine Learning). We compared the modelled CO_2 flux to Eddy-Covariance CO_2 measurements in two neighbourhood sites in Berlin for two years (2019 - 2020). The turbulent flux footprint approach was applied to estimate the CO_2 flux contributions by each component of the model. The first insights of the model's performance showed it captures well the seasonal, monthly, weekly, daily, and hourly variability of the CO_2 flux. For the site classified as LCZ 6, the MB was 0.67 µmol CO_2 m^{-2} s^{-1} and the RMSE was 6.3 µmol CO_2 m^{-2} s^{-1}, and for the site classified as LCZ 2, MB and RMSE were -0.6 and 7.8 µmol CO_2 m^{-2} s^{-1}, respectively. Our approach quantifies drivers' response to the local-scale anthropogenic CO_2 flux in wintertime, such as building emissions from domestic space/water heating and the traffic emissions from commute patterns with the peaks at rush hours, and in the summertime, the NEE of CO_2 flux from vegetation and soil. The model's design envisions the possibility of application in any city globally, specifically in areas where CO_2 emissions data are insufficient.

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Urban climate methods: Modelling

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Modeling urban surface exchange of carbon dioxide in Beijing, China

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Abstract

There is a growing need for cities to seek proper strategies to mitigate carbon emissions and prepare adaption for climate change. Here, the urban surface carbon dioxide (CO_2) flux module for the Surface Urban Energy and Water Balance Scheme (SUEWS) is evaluated against the observed CO_2 flux obtained by the eddy covariance (EC) method in Beijing for the year 2016. With high-resolution datasets of hourly resident movement, hourly traffic inventory and land use parameterized, the bottom-up modeling approach in SUEWS reproduces the averaged seasonal and diurnal variation of CO_2 flux. Meanwhile, the performance of SUEWS in modeling hourly sensible heat flux (Q_H) and latent heat flux (Q_E) remains reasonably good (R^2_{QH}=0.54, R^2_{QE}=0.56, $nRMSE_{QH}$=0.17, and $nRMSE_{QE}$=0.16). For the domain of model validation, SUEWS gives an estimated annual net CO_2 emission of 7.73 kg C m^{-2} yr^{-1}, compared with 7.45 kg C m^{-2} yr^{-1} observed by EC. Traffic is the dominant CO_2 source, contributing 79.7% of the total CO_2 emission, followed by metabolism (15.4%) and vegetation respiration (4.9%); vegetation functions as a net CO_2 sink from April to September, and it offsets 7.1% of the annual total CO_2 emission. The modeled CO_2 flux is lower than observations in the winter months; the possible explanation is that the traffic emission factor might increase as the air temperature decreases in winter, which is not yet considered in SUEWS. CO_2 flux is overestimated by SUEWS in summer, which might be explained by the underestimation of CO_2 sequestrated by the local street trees. SUEWS has the potential to be applied to examine the spatial variability and identify the hot spot of CO_2 emissions in the urban area of Beijing.

Uncaptioned visual

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Investigating Human Mobility Patterns into Seven Southeast United States Cities and its Relationship to Climatic Vulnerability

Brandon Ryan, Dr. Chandana Mitra
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Abstract

The 2000s and 2010s are decades of climate change consequences and have been mired by extreme, climate-induced disasters. There is growing concern about how these extreme environmental events and climate change will impact communities, both urban and rural, in the Southeastern United States (SEUS). A changing climate is expected to force individuals within the southeast to migrate to seek refuge from rising seas, increasing temperatures, and other environmental consequences. It is estimated that roughly 25 million to 200 million environmental migrants are expected to move within their countries by 2050. This study analyzes migratory trends into seven southeast U.S. counties (cities) (Atlanta, GA, Columbus, GA, Valdosta, GA, Birmingham, AL, Dothan, AL, Charlotte, NC and Columbia, SC). Particularly, if there are any trends which indicate migration influenced by climate hazards; and if individuals are moving into more, equally, or less climatically vulnerable (CV) destinations. Using IRS SOI Migration data, trend analysis, Distributive Flow Lines (DFLs), and new methodologies we can determine where CV individuals may be moving to within the SEUS and if there are any destinations which may be preferable to migrants' post-disaster. We found that large-scale hazards in the southeast have influenced migration into the seven counties in the past. Hurricane Katrina, for instance, likely influenced migration into Dothan, AL from Louisiana, and Mississippi in 2005. We also found that certain destination counties (cities) have been CV or have been receiving CV migrants over time. Valdosta, GA was found to be less CV over time, then counties which saw migration into Valdosta. Our hope is stakeholders, community leaders, and academics, can use this data to better understand where individuals have migrated in response to hazardous weather. This way we can bolster destination cities to have adequate resources available and the adaptive capacity to integrate displaced individuals into their communities.

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Integrated assessments of urban climate : Urban climate and climate change

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Surface and canopy urban heat island magnitudes in Europe - Uncovering differences in the diurnal cycle and sensitivity towards urban classification

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Abstract

The well-being of city dwellers is increasingly threatened by elevated urban heat. Aiming to support mitigation strategies, many studies are based on satellite-derived land surface temperature (LST) data. This has led to an tremendous increase in surface UHI (SUHI) studies which often do not sufficiently stress the differences from the canopy UHI (CUHI). This may result in erroneous conclusions and planning recommendations. First comparisons of SUHI and CUHI using LST and citizen weather stations (e.g., Venter et al. 2021) highlight this, yet comprehensive studies remain sparse. The comparison of results is further impeded due to differing UHI intensity definitions such as appropriate definitions of urban and rural. This study compares the magnitudes of summertime SUHI and CUHI for European cities using MODIS LST data at four different overpass times (approximately 01:30, 10:30, 13:30, and 22:30) and crowdsourced Netatmo-derived air temperature data. To discover the dependency of the results on the definition of urban and rural, different urban classifications are tested with respect to SUHI and CUHI magnitudes. First results will be presented with particular focus on differences between CUHI and SUHI at different times of the day by approximating the diurnal cycle with the four overpass times. The impact of different urban classifications and definitions will further be discussed.

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Urban climate methods: Observations

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Simulation of potential complex effect of urban greenery in urban canyon; case study in Prague-Dejvice

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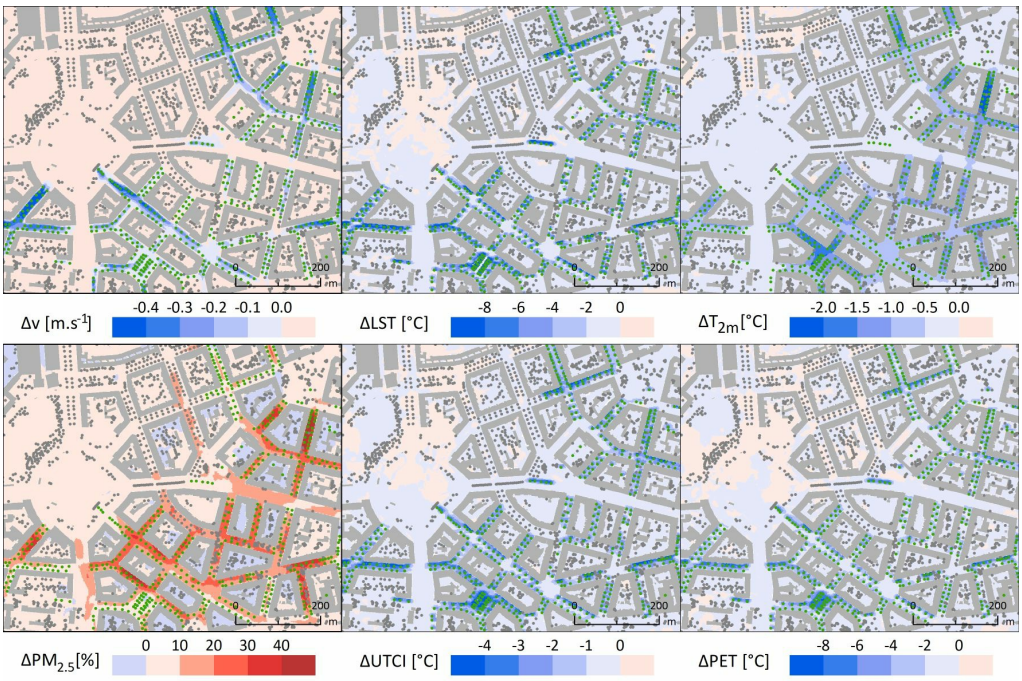
Abstract

Cities in times of climate change are one of the most current and probably the most difficult challenges local governments face. Although a large number of adaptation strategies and climate plans have emerged recently, many have a common result (at least in Central Europe); the simplest and economically most advantageous solution is usually represented by urban greenery, primarily planting of trees. Greenery in urban environments is perceived as an essential element of the face of cities and its characteristics are automatically accepted by residents as positive. The negative effects of greenery in urban areas, apart from possible allergies, are practically not considered in urban planning. However, the impact of trees in cities, positive and negative, is a significant consequence of adaptation policies, as well as the associated costs of care. Many models, mostly micro-scale, analyze the potential effect of green adaptation measures in a realistic urban environment. But the commonly used models are rarely complex enough to model air quality and thermal properties on a fine enough scale. They are typically focused on one problem only, mostly on energy-related variables (surface/air temperature, biometeorological indices or mean radiant temperature, etc.). Situation in the street canyon is more complicated, because trees change energy balance and directly affect wind velocity. Moreover, to get valid results, proper models are not a guarantee without good quality and precise enough input data. This presentation explains and summarizes the latest findings on the positive and negative effects of greenery at the street level, which were analyzed using the LES-based PALM modeling system. Selected tree-planting scenarios were considered for a typical urban environment in Dejvice, a quarter in the Czech capital, Prague, confirming the inverse effect of greenery on biomeoterological versus air quality indicators (ie. improving thermal comfort may bring about an increase of air pollution concentrations).



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Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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GLOBUS: GLObal Building heights for Urban Studies

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Abstract

Urban weather and climate studies continue to be important as extreme events cause economic loss and impact public health. Weather models seek to represent urban areas but are oversimplified due to data availability, especially building information. We introduce a novel Level of Detail-1 (LoD-1) building dataset derived from a Deep Neural Network (DNN) called GLObal Building heights for Urban Studies (GLOBUS). GLOBUS uses open-source datasets as predictors: Advanced Land Observation Satellite (ALOS) Digital Surface Model (DSM) normalized using Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM), Landscan population density, and building footprints. The building information from GLOBUS can be ingested in Numerical Weather Prediction (NWP) and urban energy-water balance models to study localized phenomena such as the Urban Heat Island (UHI) effect. GLOBUS has been trained and validated using the United States Geological Survey (USGS) 3DEP Light Detection and Ranging (LiDAR) data. We used data from 5 US cities for training and the model was validated over 6 cities. Performance metrics were computed over 300-meter regular grid. The Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE) were 5.15 meters and 28.8 %, respectively. The standard deviation and histogram of building heights over a 300-meter grid are well represented using GLOBUS.

We ingest GLOBUS derived Urban Canopy Parameters (UCP) in Weather Research and Forecasting (WRF) to estimate surface and 2-meter air temperatures at Austin, Texas. We compare the model results with temperature measurements done using mobile survey on a clear-sky summer day. Finally, we will quantify the Austin canopy layer UHI.

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Urban climate methods: Modelling

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Flood Risk Analysis in Coastal Urban Areas: A Case Study of Bangladesh

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Abstract

Bangladesh, a South Asian country, is a low-lying delta with more than half of the land’s elevation less than 8 meters above the sea level and its unique geographic location, topography and hydro-meteorological disaster proneness make it vulnerable to flooding. The 19 coastal districts cover 32 percent of the country's land area are the residence of around 25.7% of the total population. Recurrent cyclones frequently inundate the coastal regions with storm surges and the large population and the not so disaster-resilient city design contribute to the positive trend of disaster damage. So, it is important that the coastal areas of Bangladesh be evaluated on their susceptibility status to mitigate the disaster damage. The purpose of this research is to identify the flood hotspots in coastal areas of Bangladesh and to do so, land-use and land-cover (LULC) types were derived from unsupervised classification using Landsat-8 and the digital elevation model (DEM) was analyzed using the shuttle radar topography mission (SRTM) in ArcGIS Pro. Population data was also used to see the vulnerability. The result shows that the southwest and south-central parts of the coastal areas of Bangladesh has lower elevation than the southeast parts which is mainly the hilly areas. Although Bangladesh gets plenty of humanitarian help, there is a disconnect between the scientists, stakeholders, practitioners. and service providers. Plans exist mostly in reports but less evidence of the implication of disaster risk reduction in the major cities of Bangladesh. Thus, the findings are expected to be beneficial to coastal area management and disaster risk reduction.

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Urban climate processes: Extreme weather and disasters in the urban environment

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The impact of heatwave on urban heat island explained by energy budget change

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Abstract

Urban heat island (UHI) is the phenomenon where cities present a higher ambient temperature than surrounding rural areas. The origin of UHI is the change in energy balance due to urbanization. Heatwaves (HW) are extreme heat events over consecutive days and may cause negative impacts on the urban environment and human beings, such as increasing morbidity and mortality. The effect of HW on UHI remains a subject of debate as some studies have observed the synergy between them, that is, the proliferation of temperature in urban areas is likely to be higher than that in rural areas during HW events, while others have not observed the same. Meanwhile, the responses of urban and rural energy budgets to HWs have not been thoroughly investigated. To improve the understanding of the interactions between UHI and HW, the impact of HW on UHI is explored through the study of an HW event in the Greater Sydney Area of Australia in 2020 using the Weather Research and Forecasting (WRF-ARW) model. The WRF simulations cover three periods including pre-HW (23/01 – 29/01), HW (30/01 – 03/02) and post-HW (04/02 – 10/02), respectively, and the results are validated against observational data. The changes of the energy budgets including latent heat flux, sensible heat flux, radiative heat flux, stored heat flux and advective heat flux in both urban and rural areas are evaluated. The results reveal significant variations of the responses to HWs in terms of the energy budgets between urban and rural areas during daytime and nighttime, and such contrasting responses of the urban and rural energy budgets to HWs are the cause of synergy between HW and UHI.

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Multi-scale climate-sensitive planning framework to mitigate urban heat island effect: a case study in Singapore

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Abstract

Climate change is a large-scale warming trend that caused by natural and man-made forcing on the Earth's climate system. Rapid urbanization further worsens the thermal environment in the cities. As an undesirable thermal anomaly, urban heat island (UHI) becomes one of the severe environmental concerns, which brings challenges to public health and energy consumptions in urban areas. This research aims to provide a multi-scale climate-sensitive planning framework to detect and mitigate UHI effect from the perspective of urban designers and planners. Four steps are conducted in the workflow: issue identification, potential evaluation, design implementation and future projection. Morphological method is used in this study, which can be calculated quickly and applied in a large scale. A case study in Singapore is presented to demonstrate the framework. To evaluate the existing heat capability, an empirical model between sky view factor and air temperature increment was modified by local data in Singapore. Air temperature increment due to dense structure is calculated at urban scale to identify area with UHI issue with an intensity of 3°C to 4°C. Frontal area density, as a planning index that influences urban aerodynamics, is used to evaluate the mitigation potential of identified area. Climate-responsive urban design implementation is further proposed based on the balance between various climate considerations as the short-term strategy, reflected on district structure, building density, land use, building form, etc. At last, future air temperature increment due to the higher density in long-term urban planning is projected using gross floor ratio to develop the long-term adaptation measures. All the planning indices are calculated in GIS tool to support the design-driven analysis, which is highly accessible to decision-makers. This study aims to increase the intervention of climate consideration on urban design process at different spatial and temporal scales.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Urban impacts on a severe weather case over the Metropolitan Area of São Paulo (MASP)

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Abstract

Several studies over the past decades have shown that urbanization can impact precipitation amount and location. The MASP is the world's fourth-largest urban agglomeration; during summer, flash floods and landslides related to heavy rain events cause important damage. Precipitation increase over the urban area has been observed in previous studies over the MASP. However, there is still much to understand about these impacts in the future if urban areas still growing. Using a high-resolution numerical model, coupled with an urban parameterization (Town Energy Budget, TEB), we simulated a typical summer storm for three land use scenarios for 2050, in comparison with a control run: 1) prognosed urban expansion (VEG50-urban); 2) prognosed urban and agricultural changes (VEG50), and; 3) only anthropogenic heat increase (AH50) without any land use change. The model was able to well capture the diurnal cycle of temperature and relative humidity, the evolution of the storm cells, and the spatial pattern of accumulated precipitation in the control run. Average accumulated precipitation increased over the MASP by 22%, 3%, and 13% for each scenario, respectively. The precipitation rate for VEG50-urban and AH50 were also higher. With urban growth and the increase of anthropogenic heat the MASP becomes warmer and in the last case wetter, due to a higher latent heat flux from vehicles and other activities, increasing atmospheric instability, measured by CAPE, and mass convergence, enhancing precipitation over the simulated domain. The low impact for VEG50 is related to the lack of a clear pattern for instability (since convergence increase is similar to VEG50-urban), due to small temperature increase and moisture decrease over some regions in the MASP. Future simulations should assess the combined effects of anthropogenic heat and land cover change.

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Effect of building shape on the wake characteristics after a high-rise building

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Abstract

With the rapid growth of the urban population, the urbanization process continues to advance. The high and compact buildings block the air flow and alter the wind environment, thus significantly affecting the ventilation, pollutant dispersion and outdoor human comfort in the urban canopy layer (UCL). What's more, the geometries and shapes of the high-rise building complicate the wind and turbulence, which attract wide attention but need more investigation. Computational fluid dynamics (CFD) has become an effective tool for examining the effect of building shapes on the flow field and pedestrian-level wind environment around a high-rise building. In this study, with validation of data by the Architectural Institute of Japan (AIJ) and H.Tanaka et al., we examine the flow fields around a high-rise building with a 1:1:2 shape. Then, we will consider the other seven types of typical building shapes, including triangle, octagon, T-shaped, H-shaped, L-shaped, #-shaped, and cross-shaped. The mean flow and turbulence characteristics around different types of building shapes will be reported in details in the conference. Our findings can link the different building shapes to wind comfort and pollutant dispersion in the urban areas.

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Urban climate processes: Boundary layer and urban canopy layer processes

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A Comparison of Turbulent Flows over Real Urban Surfaces between Large-eddy Simulation and Wind Tunnel Experiments

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Abstract

Large-eddy simulation (LES) and wind tunnel experiment (WT) are complementary techniques for modeling the turbulent flows over urban surfaces. Most of the validations for computational fluid dynamics (CFD) model only compare the vertical profiles of mean and fluctuating velocities. Few studies look into the higher-order moments of velocity or quadrant evolutions. There is a lack of detailed comparisons of LES and WT over real urban surfaces. This study characterizes the turbulent flows over real urban surfaces using both LES and WT. The real urban morphology of the downtown district in Kowloon Peninsula, Hong Kong is resolved for CFD modeling and fabricated by 3D printing for WT. The mean wind speed and turbulent quantities (streamwise and vertical fluctuating velocities, and momentum flux) are contrasted to examine the flow characteristics over real urban surfaces. The turbulent motion scale and structures are evaluated by higher-order moments of velocity (e.g., skewness and kurtosis factors) and conditional sampling of statistics based on quadrant analysis (e.g., occurrence frequency and momentum flux fraction of sweep Q4 and ejection Q2). The results between LES and WT compared favorably that provide important implications to assessing ventilation and dispersion over urban areas, and in turn facilitate the sustainable urban environment development.

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Urban climate processes: Boundary layer and urban canopy layer processes

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Exploring the potential of Piezoelectricity as clean energy alternative in built environments

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Abstract

70% of the global energy demand has been projected to increase from emerging markets and developing economies. India, being one of the most populated countries, consumes 4% of the world's total electricity consumption with an energy shortage of around 15.2% during peak times thus highlighting the need to search for alternative energy sources. Piezo technology is a potential source for clean energy harvesting which converts dynamic mechanical energy to electrical energy. The under-floor piezoelectric energy harvesters can generate clean energy based on the mobility per unit area in built environments. Therefore, this study aims at exploring the potential of under-floor piezoelectric energy harvesters (PEH) in generating clean energy on an institutional campus. A mess building at the School of Planning and Architecture Vijayawada campus, India has been chosen for the study as the building is being used regularly throughout the year. An optimum piezoelectric tile layout that guarantees the highest stress patterns on the flooring has arrived considering the highest mobility areas/zones. Further, this mess building with optimum piezoelectric tile layout is simulated using COMSOL for a year considering the academic calendar of the institute to estimate the annual energy harvested from PEH. Additionally, the potential of piezo energy as an alternative to low intensive energy use in the building is also assessed. The study identified the zones with high mobility per unit area, coefficient of performance of piezo tiles and emplacement strategy of tiles as crucial factors that significantly affected the total piezo energy harvested. This study highlights the need to explore piezo technology as a potential source of renewable energy for wider applications in the Indian context, especially in buildings such as Shopping malls, Transportation hubs, Markets, Theatres, Institutional Buildings, campuses, etc.

Session Themes

Climate-conscious design and sustainable development : Building climates and energy

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Improved high resolution city-descriptive input data for urban meteorological modelling

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Abstract

In urban areas, high quality land cover datasets are required to take full advantage of improvements offered by sub-kilometre weather and climate simulations. At the Australian Bureau of Meteorology, we are expanding our modelling capabilities to allow ~100 m simulations over major Australian cities and so require better urban maps. We describe the Bureau's work replacing traditional single-class urban maps (e.g. IGBP or CCI) with newer, higher-quality datasets available at national and global scales (e.g., Geoscape, WorldCover, WSF3D, CCIv2 and global LCZs). We assess the strengths and weaknesses of the different datasets in terms of accuracy, fidelity, availability and impact on forecasting skill. We describe the variables available in each dataset (land cover, building and vegetation morphology, etc.), and how this impacts the configuration of different urban models. Our early and preliminary results show the highest resolution datasets with the most morphology information (e.g., Geoscape) provide the greatest benefit to forecasting skill. While Geoscape is a restricted dataset in its native resolution (~1 m), we provide a new open Geoscape-derived dataset at 300 m resolutions over the greater Sydney region, including all input variables typically required by urban weather and climate models. We also describe our methods to convert other openly and globally available high-resolution datasets to appropriate model input formats.

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Urban climate methods: Urban climate informatics

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AI-Enhanced Generation of Building-Scale Features for Urban Environmental Research

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Abstract

WUDAPT and urban and environmental researchers seek to obtain building features (e.g. building shapes, counts, and areas) at large scales (e.g., neighborhood to city scale and ultimately to region scale). However, blurriness, occlusions, and noise from prevailing satellite images severely hinders performance of image segmentation, super-resolution, or deep-learning based translation networks. During the last few years, we have been combining globally-available satellite images and spatial socio-geographic feature datasets to create an AI-enhanced generative modeling framework that enables obtaining significantly improved accuracy in per-building feature estimation as well as generation of building footprints and building layouts. Further, we observe that building layouts are discrete structures, consist of multiple rows of buildings of various shapes, and are amenable to skeletonization for mapping arbitrary city block shapes to a normalized, or canonical, form. Hence, we have developed a novel design that compensates for the degradation present in satellite images by using a novel deep network setup that includes segmentation, generative modeling, and adversarial learning for directly producing instance-level building features arranged in arbitrary city blocks and with arbitrary building shapes. Our method has proven its robustness by large-scale prototypical experiments covering heterogeneous scenarios from dense urban to sparse rural. Our results so far for urban planning, meteorology, and flooding applications show better quality and promise to future continental-scale urban applications.

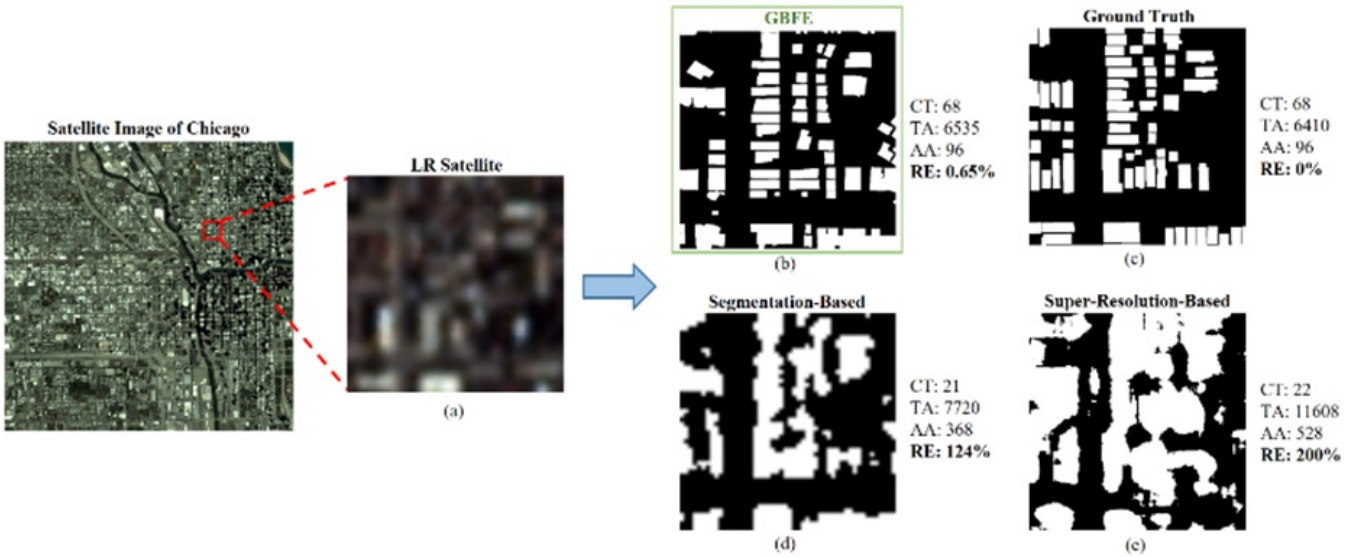

Figure: using (a) an example satellite view Chicago, we show (d) feature estimation from deep segmentation, and (e) feature estimation from super-resolution enhanced images. In contrast, b) our method notably outperforms both methodologies in terms of building counts (CT), total building area (TA), average building area (AA), and mean relative error of above three metrics (RE), while also improving building footprints – compare to ground truth image in (c). Improved results have been used so far for urban meteorological and flooding applications, for example.

Session Themes

Special Session: World Urban Database and Access Portal Tools (WUDAPT): World Urban Database and Access Portal Tools (WUDAPT)

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An open collection of 20 urban flux tower datasets

Dr Mathew J Lipson ORCID iD[1,2,3], Prof Sue Grimmond ORCID iD[3], Dr Martin Best ORCID iD[4], Dr Winston Chow ORCID iD[5], Dr Andreas Christen ORCID iD[6], Dr Nektarios Chrysoulakis ORCID iD[7], Dr Andrew Coutts[8], Dr Ben Crawford ORCID iD[9], Dr Stevan Eaerl ORCID iD[10], Dr Jonathan Evans ORCID iD[11], Dr Krzysztof Fortuniak ORCID iD[12], Dr Bert G Heusinkveld ORCID iD[13], Dr Je-Woo Hong ORCID iD[14], Dr Jinkyu Hong ORCID iD[15], Dr Leena Järvi ORCID iD[16], Dr Sungsoo Jo ORCID iD[15], Dr Yeon-Hee Kim ORCID iD[17], Dr Simone Kotthaus ORCID iD[18], Dr Keunmin Lee ORCID iD[15], Dr Valéry Masson ORCID iD[19], Dr Joseph P McFadden ORCID iD[20], Dr Oliver Michels ORCID iD[21], Dr Wlodzimierz Pawlak ORCID iD[12], Dr Matthias Roth ORCID iD[22], Dr Hirofumi Sugawara ORCID iD[23], Dr Nigel Tapper ORCID iD[8], Dr Erik Velasco ORCID iD[24], Dr Helen C Ward ORCID iD[25]

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Abstract

We present an open collection of urban flux tower datasets from 20 global sites over 50 site-years. Data have been harmonized, gap filled, quality controlled and prepended with 10 years of reanalysis-derived local data to enable use as spin-up and forcing for land surface model evaluation. For both gap filling and spin-up, ERA5 reanalysis meteorological data are bias corrected using local tower observations, accounting for diurnal, seasonal and local urban effects not modelled in ERA5. The bias correction methods developed perform well compared to methods used in other datasets (e.g. WFDE5 or FLUXNET2015). Site description metadata includes local land cover fractions (buildings, roads, trees, grass, etc.), building height and morphology, aerodynamic roughness estimates, population density and satellite imagery. This collection can help extend our understanding of urban environmental processes through observational synthesis studies or in the evaluation of land surface environmental models in a wide range of urban settings. The open dataset is accessible from https://doi.org/10.5281/zenodo.6590886.

Session Themes

Urban climate methods: Observations

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Contributions to climate-resilient city development: Proposal for urban climate studies from Kassel, Germany

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Abstract

The increasing intensity and frequency of heat waves and heavy rainfall along with urban heat islands represent a growing challenge for urban and environmental planning. Past urban climate studies have discovered many fundamental relationships that can be used to reduce the adverse effect of urban climate and climate change. The quantification and prediction, however, still require further research due to the complex interactions. This is especially true for integrated and interdisciplinary approaches and the less researched regions outside of Europe and North America.

Narrowing down the knowledge and implementation gaps through both basic and applied research in urban climatology is the main objective of the newly revived chair of Environmental Meteorology at the University of Kassel, Germany. We will apply field observations, statistical modelling and simulations, along with remote sensing to develop tools and strategies for climate-resilient planning. In this poster, we present a proposal and first results for three main near-future research directions:

(1) To generate a database for evaluating models and transferring methods to other regions, we will establish an urban climate observation network in Kassel. We are developing a systematic approach for sensor placement to study the variability of urban air temperature using local climate zones, urban climate maps and crowdsourcing data.

(2) To enlarge the benefits of the new urban climate observation network, we are planning to establish a local Climate Data Platform Kassel together with the Scientist for Future Kassel. This platform aims to make the different types of local weather and climate data from city administration, and other research institutes available and easily accessible.

(3) For narrowing the gap to implementation, user-friendly tools are needed that can assess the micro- to local-scale impacts on outdoor thermal comfort from different design options. We plan to analyse, evaluate and modify user-friendly tools to fit for practice.

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Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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An investigation into the effects of non-conventional bricks on indoor thermal environment of a building

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Abstract

India's urban population has risen from 230 million in 1991 to 300 million in 2001 to 391 million in 2011, resulting in a rapid rise in demand of residential buildings. As urban areas face elevated heat conditions due to Urban Heat Island effect, indoor and outdoor thermal comfort of the citizens are often compromised. There is huge dependence of HVAC systems in order to achieve indoor thermal comfort in hot regions. Utilization of modern construction material in buildings are one of the major reason for deteriorating indoor thermal comfort in hot regions. In contrary, vernacular architecture use locally available materials and design practices for construction which provides better indoor thermal comfort as compared to modern materials. Such materials are climate friendly, eco-friendly and sustainable. This study tries to assess the indoor thermal performance of some of the non-conventional building materials (Mud bricks, Perforated bricks and Stone) available compared to the conventional one (Red Bricks) for a hypothetical single-storey building located in a city of India having semi-arid type of climate. Simulation based technique was adopted to conduct this experiment. SketchUp was used to make a 3-D model of hypothetical building, and EnergyPlus was used to simulate the indoor thermal environment. Parameters like indoor air temperature, mean radiant temperature, relative humidity, heat transfer through walls and space cooling demand are utilized to compare the thermal performance of the chosen materials. The results, thus, obtained shows drastic improvement in indoor thermal environment during hottest days due to vernacular materials as compared to the modern materials. It also shows that the thermal properties of a building construction material plays a vital role in determining the heat transfer through walls which ultimately has effect in regulating the indoor thermal environment and space cooling demand.

Session Themes

Climate-conscious design and sustainable development : Building climates and energy

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Multi-source micrometeorological data acquisition for the assessment of heat mitigation strategies in Novi Sad (Serbia)

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Abstract

Detailed spatial and temporal micrometeorological data are crucial for tracking extreme heat and evaluating the heat mitigation potential of different strategies in cities. Field campaigns were performed in the city of Novi Sad (Serbia) on hot summer days during the period 2020-2022 to quantify the thermal conditions across the city. The micrometeorological data were obtained using a multi-source approach based on the application of: 1) Two Mobile Micrometeorological Carts (MMCs) with six-directional radiation measurements; 2) Six Kestrel 5400 Heat Stress Trackers; and 3) LANDSAT remote sensing images of Novi Sad. The MMCs were used to obtain micrometeorological data at pre-defined locations (accounting for different trees, building overhangs, exposures, etc.) on selected routes, while the Kestrel Heat Stress trackers were deployed in specific microclimate zones (e.g., urban square, urban park, street canyon, building courtyard, river quay). In addition, remote sensing data from LANDSAT were used to obtain the land surface temperature distribution across the city. In this regard, a multi-source detailed database on the micro- and bio-meteorological conditions in various urban microclimate zones was obtained. The heat mitigation potential was obtained by comparing the temperature at the reference (i.e., control) location (e.g., sun-exposed urban squares) with the temperatures in natural urban locations (e.g., under different street trees, in urban park), shaded locations by urban form (e.g., street canyons) or shaded locations by engineered/lightweight solutions (e.g., building overhangs, street canyons). Based on the data collected, the heat mitigation potential of different solutions and strategies was quantified. This approach can be applied in the development of extreme heat mitigation strategies and their evaluation using microclimate models, such as ENVI-met, SOLWEIG and PALM-4U.

Acknowledgment: This research is supported by the Extreme Heat Research Grant from the Global Disaster Preparedness Center, Red Cross Red Crescent Climate Centre, and the Global Heat Health Information Network.

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Urban climate methods: Observations

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Regional-scale shifts in precipitation due to climate change in an urban and sub-urban area

Mr Ahmad Rashiq[1], Dr Om Prakash[1], Mr Atul Kumar[2], Miss Archita Saha[2]
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Abstract

With the frequency and intensity of extreme events on the rise, global climate change is a reason of concern for everyone. The frequent occurrences of catastrophic events have resulted in an increase in natural disasters like droughts and urban floods. Major cities, in particular, have been at the forefront of this development, bearing the brunt of both unplanned urbanization and climate-induced extreme events. It hence becomes imperative to analyze hydro-meteorological parameters to get insight into the trend of extremities. Numerous parametric and nonparametric tests are done on hydro-meteorological parameters to find trends in the frequency and intensity of extreme events. In the present study, Patna city, India which experienced unprecedented rainfall in 2019 leading to massive urban floods has been taken up as the study area. Trend analysis is done using the nonparametric Mann-Kendall test for temperature and rainfall to find trends in extreme events. Further, a novel method to assess the concentration in precipitation called ‘Centroidal Day (CD)’ is used in the present study to assess the shifts in annual and monsoonal rainfall in an urban area and its surrounding suburban area. This analysis is done using the fine-scale gridded precipitation data prepared by NCMRWF at 0.25-degree resolution (12 kilometers) which is combined with ground-based precipitation data obtained from IMD. The study compares the shifts in monsoonal and annual CD values in urban and rural areas to examine how the climates differ in an urban neighborhood. The study will also reveal the regional impact of the macro climate change scenario in an urban area and its neighborhood.

Session Themes

Integrated assessments of urban climate : Urban climate and climate change

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Are the existing climate change policies in India sufficient for climate resilient cities from a heat mitigation perspective?

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Abstract

Extreme weather events are challenging the resilience of urban systems, especially in lower-income and developing countries. India is especially susceptible to severe heat waves during the summer. The recent heatwave of April 2022 in most parts of the country caused massive draught, infrastructure collapses, power outages as well as human casualties owing to the heat-related mortalities.

Climate policies and various action plans are extremely essential in this regard. The government of India proposed its ambitious goals “National Action Plan on Climate Change (NAPCC)” in 2008 towards forming ecologically sustainable development and corresponding implementation possibilities in various sectors of energy, industry, water, urban spaces, and ecologically fragile zones. One major component of this action plan is the “National Mission on Sustainable Habitat (NMSH)”.

In this current research, NMSH is analyzed component-wise to understand the efficacy of different attributes from a heat mitigation perspective. NMSH is mostly focused on building energy efficiency within urban settlement patterns with an emphasis on green buildings and site planning-related attributes. First, detailed components of the NMSH are identified, followed by that, a comparative analysis is carried out to evaluate the relative importance and significance of different attributes (urban design, landscaping, site infrastructure, and transportation) from a heat mitigation perspective. Lastly, the effectiveness of different attributes is discussed. It is concluded that the existing NMSH has partial effectiveness in generating some heat mitigation solutions at the site planning level, however, more context-specific and prescriptive solutions are required to reduce the heat stress of the occupants at the site level related to different purposes and land usages.

Session Themes

Integrated assessments of urban climate : Urban climate vulnerability in developing countries

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A two-tier sensor network for real-time monitoring and modelling of urban-scale weather in Freiburg, Germany

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Abstract

Adverse effects to human health resulting from heat stress, as well as economic losses and fatalities due to heavy precipitation events, flash floods and wind storms are concentrated in cities, and often large intra-urban variabilities are present. Weather sensor networks (WSNs) that monitor meteorological conditions play a vital role in quantifying, mapping and downscaling potential hazards. Existing WSNs, however, are typically limited to coarse networks or do not provide any data beyond air temperature and humidity needed to map, for example, thermal comfort.

Here, we present a customizable two-tiered WSN setup for urban weather and climate monitoring. The hierarchical urban canopy-layer network developed in Freiburg, Germany, consists of two different station systems that are integrated into pubic street lights at a uniform height of 3 m a.g.l.. Fifteen “tier I stations“ are strategically placed in representative built-up and rural areas. They are equipped with a ClimaVUE 50 all-in-one weather sensor (precipitation, wind, radiation, temperature, humidity, pressure, lightning) and a Black Globe Sensor (Campbell Scientific, Inc.) which enables real-time thermal comfort calculations. Tier I stations feature a custom-built multi-purpose logger which is controlled by a Raspberry Pi Zero running a custom remote control software and GSM data transmission. This allows for a flexible setup that can easily be expanded to include additional sensors. In addition, to increase the spatial density of the WSN, 35 “tier II stations“ (LoRAIN, Pessl Instruments GmbH) measure air temperature, humidity and precipitation and transmit data over NB-IoT.

With measuring and transmission intervals of one and five minutes, respectively, one major purpose of this WSN is to develop machine learning routines for data quality control in real-time and downscaling of data from tier II to tier I stations. Moreover, the WSN will provide input and validation data for numerical high-resolution modelling of urban heat, dynamics and hydrology.

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Impact of trees on microclimate in a row house development during summers in hot and dry climate: A case of Amravati, Maharashtra.

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Abstract

Buildings in hot and dry climate becomes hot spots due to heat waves thereby increasing the thermal discomfort of the occupants considerably. Many residences in low-income neighborhoods especially in India, do not have active cooling systems and they majorly depend on passive techniques to mitigate harsh climatic conditions. Passive techniques such as building orientation, shading, fenestration design, daylight distribution, passive cooling, energy efficient materials, etc., are considered for buildings in hot and dry climate. In addition, the use of vegetation for simple shading also have been proven beneficial to enhance the building performance. The strategic placement of the native species in the form of trees, shrubs and other vegetation provide shade by forming natural umbrella, thus reducing the incident radiation, surface temperature and internal heat transfer, and enhance comfort conditions. Therefore, the main aim of this study is to improve the microclimatic conditions in a low-rise residential development through assessment of the impact of trees on meteorological parameters and thermal comfort. A shoe-box model of a row house residential development at Amravati, Maharashtra, with four different vegetation scenarios such as without vegetation, with shrubs, with trees and with shrubs and trees were considered for the study, and the daytime and night time variation of the microclimatic parameters were assessed through Envi-met simulations. The findings of the study revealed that air temperature did not show significant difference with changing vegetation scenarios. However, relative humidity increased with significant reduction of 5˚C in the mean radiant temperature (MRT) in the scenario with trees and shrubs during day time. Also higher wind speeds were found in the first scenario without vegetation which reduced marginally with the addition of vegetation in the setbacks. The study found that introduction of trees and shrubs in the setbacks in hot and dry climates enhanced the microclimatic significantly.

Session Themes

Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Global Investigation of the Cooling Effects of Urban Parks Using Satellite-Derived Land Surface Temperature

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Abstract

Vegetated parks form localized cool spots within the warmer urban fabric. The influence of the cooling typically extends beyond park boundaries, affecting the surrounding built-up area through advection. The daytime surface Park Cool Island (PCI) effect is assessed here globally, using the Landsat Collection 2 Level-2 Surface Temperature product (2013-2021) through the Google Earth Engine platform. Over 5000 parks are studied in 495 global cities; parks were picked in such way that in their vicinity the cooling influence from other greenspace is greatly limited. PCI intensity is computed and associated to the park size and shape; next, the extent of park-induced coolness and temperature gradients are derived. The urban-park surface temperature differences are further investigated for seasonal and macroclimatic influences. Finally, controls on PCI exerted by weather (regional wind speed, rainfall) and extreme events (heatwaves, droughts) are estimated using daily reanalysis data (ERA5).

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Subtropical Vienna - Designing Urban and Architectural Microclimates for a Collective Form of Climate Adaptation

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Abstract

The research project investigates the role of collective urban and architectural form in the climate adaptation of cities. Vienna is projected to change its climate to the humid subtropical (Cfa) zone by 2050 and will be one of the cities most severely hit by future heatwaves due to its population density. Yet, it’s consolidated urban fabric carries significant potential for architectural climate adaptation and therefore serves as a test case.

In continuation of evidence-based urban design methods developed by R. Knowles, V. Matus, and A. Klein the project seeks for collective strategies of climate adaptation on three case study sites. Different adaptation scenarios are tested in an explorative design research methodology. Employed tools include on-site surveys, 3D CAD modelling of existing buildings and computational climate simulations.

Urban climates have a distinct quality exerted by their building fabric. The description of the “artificial” quality of the urban microclimate and the effect of built form was first laid out by Schmidt, Tollner and Steinhauser in Vienna at the beginning of the 20th century. Their work partly served as the scientific basis for a beginning correspondence between Climatology and Architecture, making the urban climate a matter of design. This thesis aims to renew this link by integrating current microclimatological knowledge and simulation tools in the design process.

While the focus of urban climate adaptation today lies on blue and green infrastructure, the results of this research project highlight architectural techniques of urban climatization. Altogether, the project presents knowledge of urban-climatic design that could inform a new strategy of municipal thermal governance for the unprecedented shift of cities to a new climatic zone. Understanding, visualizing, and designing daily and seasonal cycles of climates, uses, and rituals stands at the center of this research project.

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Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Parametric Design Applications at the Building and District Scale: A Performance-Based Iterative Design Process in a Hyper-Arid Climate

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Abstract

Climate sensitive district-scale planning is key for cities to achieve their climate goals. Yet much of these approaches are disconnected from the multi-scalar and iterative nature of the design process. Such a process requires parametric applications as additional feedback loops to the conventional iterative design process between issues of performance and design using environmental controls and criteria as an integral part of design concept development. A multi objective optimization design workflow is piloted using Kuwait's hyper-arid desert climate and it's prevailing single family detached residential landscape. Both, architectural and urban design intentions were soundly informed through parametric and optimization analysis of solar radiation, views, daylight, and building energy use. Results of the piloted workflow identifies the often lost opportunities in responding to environmental controls available in the local climate and the proper utilization of site features and architectural design elements. The findings of the proposed performance-based iterative design process also provide insights on the necessity of interventions to happen at the building as well as the district scale for cities to achieve district-wide energy savings which would ultimately modulate urban induced heating.

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Climate-conscious design and sustainable development : Climate-sensitive urban design and planning

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Resolving micro to mesoscale interactions between urban surface and a sea-breeze circulation using high resolution large-eddy simulations

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Abstract

The coastal urban boundary layers are characterized by a high degree of surface heterogeneity and complex dynamics associated with interactions between land and marine air masses. The subsequent broad range of relevant spatial and temporal scales associated with them makes them difficult to numerically model and to theoretically describe.

One example of a coastal meteorological phenomenon arising from surface heterogeneity is the sea-breeze, observed also in numerous coastal urban areas around the globe. The general sea-breeze circulation has associated spatial scales ranging from one to hundreds of kilometres. However, it is influenced by surface exchanges, which have spatial scales down to metre-scale in urban areas. By using novel multi-scale modelling methods capable of resolving the most relevant scales of interactions, our aim is to study the boundary layer processes during a realistic springtime sea-breeze case in Helsinki, Finland.

The PALM model system, an open source meteorological modelling system for boundary layer flows, has implemented the capability for multi-scale two-way self-nested large-eddy simulation (LES) setups. Setups of several self-nested LES domains are especially suited for studying problems such as the interaction between the urban surface and the sea-breeze circulation.

We study both the mechanical and thermal influence of the urban surface on the development of the mesoscale circulation. Furthermore, we investigate how the urban surface affects the development of the thermal internal boundary layer in the lower branch of the cell, where the stable marine air mass is advected over land.

In order to verify the simulation setup and the results obtained, we compare the results with observations from Doppler lidars, a dual-polarization weather radar and an in-situ measurement network being operated in the region. We anticipate that we will gain exciting new insights into the development of a sea-breeze circulation and thermal internal boundary layers in coastal urban boundary layers.

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A Comparison of Integrated Urban Flood Risk Management in Various Climatic Zones.

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Abstract

The urbanization trend is one of the main drivers of flood susceptibility and has become a global concern. Other factors contribute to urban flood scenarios in different nations, including climate change, harsh weather, industrialization, deforestation, increased impermeable land, population growth, incorrect land use, unsustainable natural resource management, etc. The critical climate change components impacting urban floods are global warming, sea-level rise, and natural variability in rainfall. Flood risk management encompasses structural and nonstructural measures. Hard-engineered structures such as flood barriers and drainage channels are structural measures, whereas wetlands and natural buffers are examples of more natural and sustainable supplementary or alternative solutions. Nonstructural solutions, unlike structural measures, do not need a significant investment in hard-engineered facilities but instead, rely on a thorough understanding of flood danger and practical forecasting tools. An integrated flood risk management (IUFRM) method is a set of strategies that, when combined, can effectively minimize urban flood risk. IUFRM focuses on all types of flooding and balances structural and nonstructural management strategies based on stakeholder objectives and environmental conditions. This comprehensive strategy is becoming increasingly crucial in assuring safety and long-term viability. Buenos Aires, an Argentine city, implemented integrated urban flood risk management by merging structural measures such as improved drainage systems and flood readiness for susceptible regions not protected by structural defenses. However, there is a need for an appropriate urban flood risk management guideline concerning a city’s context, stakeholders, and distinguished climatic conditions. Several successful instances of integrated urban flood risk management in various cities demonstrate that, with the proper methods, urban flood reduction is achievable. This paper aims to analyze case studies from different climate zones to understand critical factors related to implementing IUFRM strategies.

Key Words: Integrated Urban flood risk management, Urban flood, Global warming, Climate change, Urbanization, Structural measure, Non-structural measure.

Session Themes

Urban climate processes: Urban hydrology

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Chasing the plume – Investigating the urban boundary layer downwind of a city with transects of fixed and mobile profiling instruments

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Abstract

To better understand dynamic interactions between a city and the regional atmospheric boundary layer, the '*urbisphere*-Berlin campaign' is being conducted from Autumn 2021 to Autumn 2022 in Germany within the ERC Synergy '*urbisphere*' project. *urbisphere* aims to enhance understanding, forecasting, and projecting feedbacks between climate change and drivers of urban transformation. The focus of the Berlin campaign is to investigate the dynamics of the atmospheric boundary layer within and beyond the city. The campaign involves state-of-the-art observations for process understanding, model development and evaluation.

One campaign foci is the urban boundary layer. A dense network of ground-based remote sensing instruments (e.g. automatic lidars and ceilometers ALC, doppler-wind lidars DWL) are used to determine the aerosol characteristics and mixed/mixing-layer-height within the city and along a rural-urban-rural transect. Mobile measurements using a van-mounted ALC during IOPs (Intensive Observation Period) in spring and summer, provide greater spatial coverage and resolution. At the same time weather sondes were released in and outside of the city, giving profiles of air temperature, humidity, wind speed and direction. Combined, the IOP and fixed measurements are used to estimate the horizontal and vertical extent of the urban plume.

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Urban climate processes: Boundary layer and urban canopy layer processes

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Effect of radiation interaction and aerosol processes on ventilation and aerosol concentrations in a real urban neighborhood in Helsinki

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Abstract

Thermal turbulence is known to have an effect on urban boundary layers and turbulent mixing. This paper aims to quantify the effect of thermal turbulence and aerosol processes on aerosol concentrations and dispersion in a real city enviroment by using a high resolution LES model called PALM, coupled with the radiation module RRTMG. Dynamic boundary conditions supplied by the numerical weather prediction model, MEPS HARMONIE are responsible for driving the early summer morning simulations in Helsinki, Finland on the 9th of June, 2017. Radiation interaction increased near surface temperatures from 8.6 C to 12.5 C, which enhanced the flow field such that it caused a reduction in mean total particle number concentrations at pedestrian level (4m) of 52%, while horizontal wind speeds increased by 78% at the same height. A topographically forced street canyon vortex already present in the neutral case was strengthened and stretched vertically within the canyon. The largest difference in total particle number concentrations is observed when radiation interaction is on, which increased ventilation due to thermal turbulence. Analysis of spatial means and both averaged areas and profiles were the main tools used in the data analysis. These results show that including radiation into aerosol dispersion simulations is important due to the changes in the flow patterns within the canopy layer caused by the change in stratification from neutral/stable to unstable.

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Urban climate processes: Boundary layer and urban canopy layer processes

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Simulation of urban forms effect on localized urban heat island and its consequences on building energy demand in Morocco

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Abstract

Most cities, and particularly in Morocco, are designed without considerations of the resulting changes in microclimatic conditions. Urban Heat Island (UHI) is closely related to urban forms. The form and layout of buildings and streets affect considerably radiative and heat exchange and disturb air temperature distribution inside the city. This might cause an increase in electricity usage as the population uses air conditioning to provide thermal comfort. In a previous study (figure 1), we showed that in Marrakech, a semiarid city in Morocco, an increase of 1◦C in the maximum mean air temperature can cause an increase in energy use of 4.4% at city level. In this study we use the Urban Weather Generator (UWG) combined with a building's energy simulation software (Energy plus) to estimate the local hourly air temperature in different urban settings and its impact on energy demand for heating and cooling in a typical Moroccan residential building.

The simulations are conducted on the same building scheme but in different neighborhood context and different climates. The resulting differences in normalized energy demand explain the local UHI impacts and help determine the most effective urban design strategies for each climate zone in Morocco.

Keywords: Urban Heat Island, Urban Forms, Energy Demand, Urban Weather Generator, Energy Plus

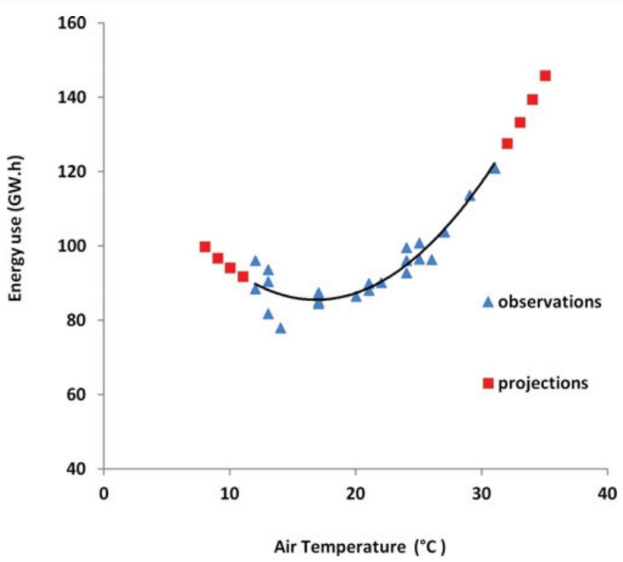

Figure 1: Monthly energy use (GW.h) versus observed mean air temperatures recorded during the years 2013 and 2014 in Marrakech (Lachir et al., 2016)

Session Themes

Climate-conscious design and sustainable development : Building climates and energy

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Simulating pedestrian winds comfort in public space during a rapidly developed urban area. A case study of in Nanjing (1930s-2000s)

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Abstract

Rapid urbanization especially features of high-rise and densitified development has left remarkable impact on micro-climate as winnessed in many Chinese cities. It’s essential for urban designers and decision-makers to contextualize pedestrian comfort in the public space and micro-climate changes. A longitudinal study of such circumstance will provide knowledge and lessons for sustainable and salutary urban design.
Based on CFD simulation, this paper compares the winter and summer wind patterns of an area in downtown Nanjing, from the 1930s to 2000s. The results indicate that the wind pattern complexity increased gradually, the outdoor comfortability degraded dramatically in some areas, the environment inequity may be deteriorated too. This study suggests to put micro-climate issue firmly on the agenda of public wellbeing policy, involve various stakeholders in the assessment and urban design code with technical and social supports.

Keywords: CFD simulation, public space, pedestrian comfort, urban design, longitudinal study

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Integrated assessments of urban climate : Urban climate vulnerability in developing countries

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An investigation into the effects of different types of building shading elements on indoor thermal environment.

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Abstract

Abstract:

Modern architecture now mostly prefers larger glazing façade for better aesthetics. The larger glazing façade creates the problem of building overheating by transmitting direct solar radiation indoors. In such buildings, the shading devices should be carefully selected and installed. Shading of a building façade with glazing surfaces is crucial and important in the regions facing hot weathers. Shading devices obstructs the incoming direct solar radiation and restricts the solar transmittance through windows. In this study, the indoor thermal performance of different internal and external shading devices is assessed for a building located in a city of India observing semi-arid type of climate. The 3-D model of the building was developed in SketchUp and the thermal performance simulations were conducted using EnergyPlus. Shading elements like Overhangs (actual scenario), Louvers, Egg-crates and Internal Blinds were studied and compared. Thermal performance of shading devices was assessed for the south façade of the building during Pre-Monsoon season (May). Comparison was based on the parameters like indoor air temperature, solar radiation transmitted through windows, mean radiant temperature and relative humidity due to all four shading elements. The simulation results showed that the louvers were able to obstruct the incoming solar radiation in higher amount as compared to other shading devices during summers. This ultimately resulted in lower Mean Radiant Temperature.

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Climate-conscious design and sustainable development : Building climates and energy

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A semi-empirical model for the effect of trees on the urban thermal environment

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Abstract

Tree planting in urban areas has the potential to improve the urban thermal environment and mitigate the Urban Heat Island effect. However, many models oversimplify street canyons with trees and the interactions between the built environment and vegetation, at the expense of high computational cost. In this study, we present a quick and practical semi-empirical model for the landscape planning of urban vegetation. Urban Tethys-Chloris (UT&C) is a coupled energy and water balance model that calculates pedestrian air temperature (*Ta*), relative humidity (*RH*), and thermal comfort index based on the input background meteorological data and parameters of street and vegetation. In particular, we improved the wind speed calculation in the UT&C based on the balance between momentum flux and the drag force of both buildings and trees on airflow. A validated analysis of the model performance was conducted through a comparison with a scaled outdoor experiment in Guangzhou. Cases of two-dimensional (2D) street canyons (aspect ratio = building height/street width, $AR=H/W=1$; $H=1.2$m) without and with double-row trees (species: *Cinnamomum kotoense*) were selected for the validation. The results can be summarized as follows. (1) The calculated and observed *Ta* (*RH*) show the good agreement with the high R^2 of 0.97 (0.98) and 0.89 (0.74) for the tree-free and vegetated street; (2) Model and observation both report a maximum *Ta* reduction (cooling) of about 3.0 ℃ caused by trees. However, the calculated peak cooling is about 3 hours later than the observed peak cooling, probably due to heat storage functions in UT&C; (3) The model tends to overestimate the increase of *RH* provided by trees' evapotranspiration; (4) After the modification of wind functions in UT&C, the performance of wind speed calculation is improved significantly and also lead to the improvement of the *Ta* calculation.

Session Themes

Urban climate methods: Modelling

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Space Measurement of CO2: A remote sensing and urban microclimate study of CO2 sources and sinks

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Abstract

The emergence of the Industrial age has resulted in increased atmospheric carbon dioxide (CO2) concentration due to intense urbanisation. Another consequence of anthropogenic events is urban microclimate modification, which plays a vital role in carbon source and sink. The characteristic of urban area, such as; land use, construction material, morphology, and transportation, all contributes to CO2 emission. Whilst human-caused CO2 emissions are substantially smaller than natural sources, they have thrown off a natural balance that existed for centuries before human intervention. Furthermore, the alteration of microclimate, such as increased temperature, contributes to higher energy demand for thermal comfort. Also, high temperature and urban roughness reduce wind speed which inhibits the horizontal movement of CO2 to regions such as forests that act as a carbon sink. This research measures the concentration of CO2 across various land use and microclimate conditions using NASA's OCO-2 and OCO-3 satellite data. This is done by accounting for the column average volume mixing ratio known as XCO2 at different periods. In addition, the OCO mission provides insight into the sources and sinks of CO2 in the atmospheric column within the lower troposphere because it is sensitive to spectral radiance in the near-infrared (NIR) CO2 bands. Thus, the effect of the microclimate condition is examined using ENVI-met CFD simulation. Furthermore, the impact of urban roughness and windspeed variation is assessed by analysing local climate zone (LCZ) classification at regional scale. This study provides insights into the anthropogenic factors that increase CO2 concentration. Ultimately, it will enhance a climate-sensitive urban design that could mitigate GHG emissions, which is a critical step in combating climate change.

Session Themes

Urban climate processes: Urban air quality

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Parametrizing drag distribution over an urban canopy with variable building height

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Abstract

The research attempts to model the drag coefficient over an urban canopy with variable building height. Large-eddy simulations were carried out in a wide range of the primary parameters of urban morphology; the plan area indices, aspect ratios, and standard deviation of building heights. The velocity profiles are found to be expressed by the region to three layers; the layer of an equilibrium logarithmic profile, the layer of an exponential velocity profile, and the intermediate layer of the wake due to the building height variability. The last layer was further analyzed in a view of the momentum balance throughout the urban canopy.
The simulated velocity profiles indicate the similarity in the layer of an exponential profile even though the degree of the building height variability differs. Based on this finding, we attempted to model the drag coefficient of the intermediate layer by the frontal area index of the corresponding layer.

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Urban climate processes: Boundary layer and urban canopy layer processes

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Potential of satellite observations to detect and monitore urban aerosol signal over Paris urban area (France)

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Abstract

Cities impact local air quality and microclimate, in particular by creating urban heat island (UHI). UHI is governed by urban characteristics and local weather conditions. Activities in the city also generate local emissions of pollutants and particles. However, only few studies have focused on the interactions between urban aerosols, radiation, and UHI. Yet, spatial distribution of aerosols can highly fluctuate and have a significant impact on incident solar radiation. Thus, it is necessary to accurately assess the spatial and temporal variability of aerosols in the urban atmosphere in order to evaluate their interactions with UHI. Satellite data are particularly relevant data to monitore atmospheric aerosols above cities.

In order to study the potential of satellite measurements to detect urban aerosol signal over Paris, 15 years (2006 to 2020) of MODIS MAIAC AOD (Aerosol Optical Depth) satellite product (1 km of resolution) have been analyzed, on a 200 km squared domain. Additional surface PM10 data (from AirParif air-quality monitoring network) and local weather observations completed the analysis. A land-use mask derived from the Corine Land Cover database was used to defined urban and rural areas.

First results present, both in urban and rural areas, a slight decrease of AOD from 2006 to 2020. The seasonal analysis of AOD shows a peak of aerosol concentration during spring and summer and a minimum in autumn and winter. Furthermore, a weak but significant positive signal over Paris urban area (ΔAOD = AODurban – AODrural) is observed throughout most of the year with a maximum in autumn.

The comparison between MAIAC AOD, surface PM10 concentrations, and local weather conditions emphasizes a variability of the urban signal and of the link between AOD and surface particle pollution depending on the large-scale conditions (especially, strength and direction of synoptic flow) and the development of the atmospheric boundary layer.

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Urban climate methods: Observations

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Analyzing the effects of urbanization on land surface characteristics on two cities utilizing Google Earth Engine

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Abstract

Urbanization in the coastal regions is expected to further intensify in response to population growth and increased demand in ocean-side properties. As urbanization occurs, coastal plain cities are faced with intensified environmental pressures that can negatively impact the land-atmosphere interaction processes. The objective of this research is to assess the intensification of atmospheric impacts of land cover and land use (LCLU) change in coastal settings (especially urbanization), such as urban heat and vegetation. In this research, two coastal cities, Thiruvananthapuram (Trivandrum) and Naples, are being evaluated. Small and medium cities are crucial to examine as they are not commonly studied, though they significant population growth, making it essential to evaluate their environmental status. These areas were specifically chosen for this comparative study based on similar latitudes in two different regions, developing versus developed and for their size.This study focuses on the effects of urbanization on the land surface characteristics of Trivandrum and Naples, utilizing multiple decades satellite observations from Google Earth Engine (GEE). The data collected over a 20-year time span (2000-2020) is from GEE are from Moderate Resolution Imaging Spectroradiometer (MODIS), which provide unprecedented opportunities to conduct spatio-temporal change analysis of urban regions. This research uses multi-decade National Aeronautics and Space Administration (NASA) satellite observations to comprehensively analyze urban LCLU atmospheric impacts in coastal region and other geographic settings where they are amplified. The city of Trivandrum has been analyzed, while work continues for the city of Naples. The significance of this research is that it indicates there are mass changes in both cities over the 20-year time lapse with distinctive land surface temperature increase and loss of vegetation due to urbanization in two coastal cities with different growth patterns and economic status.

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Integrated assessments of urban climate : Urban climate and climate change

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An assessment of Diurnal and seasonal variations of Surface Energy Fluxes in a hot tropical Humid City with SUEWS

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Abstract

Urban heating has been evident in sub-Saharan Africa; however, little is known about the urban heating processes. This study analyses the urban heating processes of Lagos (Nigeria) which is Africa's most populous city, located in a hot and humid climate. We examine the characteristics of Lagos' urban landscape using Local Climate Zones (LCZs) and explore the spatial and seasonal variations of surface energy fluxes and temperature. The LCZ map was created using the LCZ generator (https://lcz-generator.rub.de/), which was used to derive parameters for the Surface Urban Energy and Water Balance Scheme (SUEWS) using python (SUPY).

Lagos landscape consists of few compact high- (LCZ 1) and mid-rise (LCZ 2) types in the city centre, surrounded by a large compact low-rise (LCZ 3) in the outer area and then open low-rise (LCZ 6) and scattered housing (LCZ 9) in the suburban areas. The impact of this landscape heterogeneity on the energy fluxes was evaluated using SUEWS model forced with ERA5 surface data. Model validation exercise showed an acceptable comparison between modelled and observed meteorological outputs which align with previous findings for midlatitude regions, suggesting that the model could perform well in a humid tropical climate. The spatio-temporal distributions of energy fluxes showed that the turbulent heat fluxes increased significantly particularly in the city centre LCZs whereas suburban LCZs have greater latent heat flux magnitudes due to the large area of vegetation and pervious surface cover. We also noted a significant increase in the Bowen ratio in city centre LCZs particularly at night which is marked by great variability across other LCZs.

Generally, the results showed significant intra-urban and seasonal variations in the energy fluxes. The result also demonstrates the capability of SUEWS model with readily available inputs in estimating the variations in surface energy fluxes in a tropical humid city.

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Urban climate methods: Modelling

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Blue space effects in a simplified urban neighbourhood under neutral stratification

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Abstract

The combined effect of climate change and future urban growth will further increase air temperatures in cities, contributing more to what is known as urban overheating. There is a growing awareness that Nature-Based Solutions (NbS) – actions inspired by, supported by or copied from nature – can contribute to climate change mitigation and adaptation within cities. Nonetheless, although the incorporation of NbS, comprising green and blue infrastructure, is often touted as a way to cost-effectively cool cities and enhance pollutant removal, there is little agreement between different methodologies to measure the effect of any single intervention. This is particularly true for blue spaces, i.e. urban ponds, lakes and wetlands, which are significantly less studied. This poster presents the main results of a novel study on the influence of urban blue space on in-canyon airflow and temperature/vapour distribution, and the associated implications on pollutant removal in a simplified urban neighbourhood. Using a validated solver that accounts for evaporation and buoyancy, we examine the performance of an isothermal waterbody in a neutrally stratified atmosphere under forced- and mixed-convection regimes and different air-water temperature differences, indicative of either daytime or night-time conditions. Results for forced convection show minimal impact on the flow structure, whilst temperature/vapour effects are distributed primarily over and around the water surface. However, the mixed-convection case shows that a cooler waterbody weakens the principal vortex in the open square, whilst temperature/vapour effects reach further upwind and are more widely distributed in the spanwise direction. A warmer waterbody is shown to disrupt the skimming flow structure, indicating a possible heat and pollutant removal mechanism from around the waterbody and the downwind canyons.

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Study of the future evolution of the urban climate of Paris by statistical-dynamical downscaling of the EURO-CORDEX ensemble

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Abstract

Because of the already apparent effects of climate change on urban areas, stakeholders and policy makers need local climate change information that is tailored to the specificity of cities in terms of spatial and temporal resolution and impact indicators. The latest generation of climate models is capable of representing cities explicitly, but due to its high computational cost, only a small number of models and scenarios can be simulated and only for short periods. Here we present the results of a statistical-dynamical downscaling framework applied to the Paris region in France, which downscales the EURO-CORDEX regional climate model ensemble for two emission scenarios over the period 1970-2100. The statistical-dynamical model is adapted to drive the SURFEX platform, which integrates the TEB urban canopy model to simulate the evolution of the urban climate of Paris. Several indicators are studied such as the evolution of urban heat islands, thermal comfort of inhabitants and the energy consumption due to heating and cooling of buildings. The results show that the average urban temperature will increase by about 4°C between 2070-2099 and 1976-2005 in summer under a high emissions scenario and by 2°C under a more moderate emissions scenario. Associated with this increase, the thermal comfort of the inhabitants will improve in winter with a decrease in "cold stress" conditions (UTCI < 0°C) but will strongly deteriorate in summer with "hot stress" conditions (UTCI > 26°C, 4 hours per day to 8). As a consequence, the energy consumption due to heating in winter will decrease strongly (about -30%) while the energy consumption due to cooling, which was almost non-existent, will increase massively (more than 5 times). Nevertheless, the energy consumption for cooling will still be an order of magnitude lower than for heating (about 3 kWh/m² versus 40 kWh/m²).

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Integrated assessments of urban climate : Urban climate and climate change

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Assessing Urban Climate in North-East cities of India through a Multi-dimensional Approach

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Abstract

The 6th IPCC report (2021) highlights that India continues to face irreversible impacts of the climate crisis. As more people will live in urban areas, the exposure to climate change impacts increases over time. Vulnerability to extreme weather events and disasters cause disrupt the life and livelihood of people residing in such settlements over a period of time. With the shift in extreme weather patterns, North-East India continues to face the climate change impacts. In the state of Assam, the impact of such events have an adverse effect on different levels and stakeholders. This study attempts to bring a multi-dimensional approach to the forefront by integrating Spatio-temporal assessment at various scales and rationalizing a way forward by processing qualitative and quantitative data. The study assesses climate patterns in urban areas of cities in Assam for understanding the urban determinants as well as long-term resilience building.

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Can cool roof and green roof mitigate urban heat and improve the human thermal comfort during extreme heatwave condition?

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Abstract

The intensity and frequency of extreme heatwaves have dramatically increased in the Indian sub-continent. In the urban area, climatic risks are extra prominent due to regional climate change. This study evaluated the effectiveness of cool and green roof to mitigate the urban heat and cooling effects on human thermal comfort for a tropical coastal city during heatwaves. We employed the weather research and forecasting model coupled with the single-layer urban canopy model (WRF/SLUCM) for assessing the effectiveness of these two promising heat mitigation technologies. Further, human thermal comfort was calculated from high-resolution climate outputs from WRF/SLUCM as universal thermal climate index (UTCI) using the RayMan model. The results revealed that city-scale deployment of 100% cool roof can considerably reduce the near-surface temperature and surface skin temperature (up to 2.3 °C, and 5.9°C, respectively) during peak hour (14:00LT). The deployment of 100% green roof can also reduce the near-surface air temperature by 1.1°C during peak hour (14:00LT). Besides the temperature reduction, both technologies showed lower wind speed, lower mean radiant temperature, and higher relative humidity as compared to the reference scenario. Implementing the highly reflectively materials and rooftop vegetations during heatwave events led to decrease the lower atmospheric dynamic with low-level vertical mixing and lower height of urban boundary level. During the heatwave period, cool roof technology can provide the overall reduction of UTCI than the green roof and shorten the duration of heat stress from 8 h d-1 to 6 h d-1.

Keywords: Urban heat, Heat mitigation, Thermal comfort, Mesoscale climate model, Kolkata

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Biometeorology & health: Urban microclimate and comfort

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Highlights of the WUDAPT Decade

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Abstract

The World Urban Database and Access Portal Tools (WUDAPT) project was launched in Dublin at the 8th International Conference on Urban Climates ten years ago. WUDAPT was conceived as a community-based initiative to address the data ‘gap’ that inhibits the application of urban climate knowledge to cities, globally. It was devised to support environmental modeling tools and studies capable to address the urban climate effect, including the exposure of cities to current and projected hazards because of the character of urbanization. It employs novel and pragmatic approaches to acquire consistent data on the form and functions of cities at useful spatial resolutions. At the base level, WUDAPT adopted the Local Climate Zone (LCZ) typology to map urbanized landscapes and derive urban canopy parameters (UCPs) for models, the LCZ project has evolved from mapping individual cities, to regions, and to continents. The most recent product is a first global LCZ map at a scale of 100m. This evolution has been supported by developments in the capacity to utilize a large array of satellite products within the framework of quality training areas and machine learning. Concurrently, these LCZ data have been incorporated into widely used models such as SUEWS and WRF. It is now feasible to perform intraurban, multi-scale model applications based on a universally consistent urban canopy layer methodology on issues pertinent to this era of great Anthropocene challenges. Building on this LCZ framework and achievement, WUDAPT is advancing other innovative e.g., cyber-based methodologies to facilitate the generating of unique block scale grid specific UCPs for advanced intracity applications and studies. A Special Issue of Urban Climate on this WUDAPT Decade is being established, a platform dedicated to highlighting these and future advancements and towards stimulating myriad of urban focused multi-scale fit-for-purpose modeling applications pertinent to addressing climate change challenges.

Session Themes

Special Session: World Urban Database and Access Portal Tools (WUDAPT): World Urban Database and Access Portal Tools (WUDAPT)

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Scientists, Practitioners, and a Disconnect: Perspectives on (Un-) Intended Co-benefits, Trade-offs, and Disservices of Heat Mitigation

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Abstract

Communication between scientists and practitioners is key to improve resilience against human health threats such as extreme (urban) heat. **Heat and its mitigation** is paramount to achieving **sustainable development goal (SDG) #11** “Sustainable Cities and Communities,” but scientists and practitioners are expected to have a distinct perception of heat mitigation strategies. This could cause misunderstandings about the effects (co-benefits, trade-offs, or disservices) of heat mitigation strategies leading to potential unintended consequences after application. Those consequences could outweigh the intentional heat mitigation impact when considering, e.g., cost or population health. This **disconnect** between the knowledge producers (basic) and the knowledge users (applied) is considered the **basic-applied paradigm**. Outcomes such as misinformation and biased evaluations of the strategy itself could create an inequitable and unsustainable implementation because heat mitigation planning requires a considerable amount of diverse information from environmental to social to economic resources.

Thus, this work showcases **preliminary results** of a **systematic literature review and content analysis** to determine the communication disconnect and understand the different perspectives of (un-) intended effects of **green infrastructure and cool pavement** in the **original heat mitigation research and US urban practitioner literature**. The focus is on green infrastructure and cool pavement because green infrastructure is a well-researched strategy with many examples of implementation in the real world while cool pavement has its first real-life implementations with comparatively less disciplinary and interdisciplinary research. Understanding the differences between co-benefits, trade-offs, and disservices is **critical in overcoming the basic-applied paradigm** between science and practice, allowing improved communication and the potential co-creation of usable science for heat mitigation and beyond. This work will provide a foundation to understand and work towards overcoming this basic-applied paradigm, which will **improve efforts towards the SDG #11**.

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Effective vegetation models for urban climate simulation

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Abstract

The effect of green spaces on the inner-city climate is manifold, but controversial. Considering the thermal conditions explicitly, the shadow effect and evaporation seem to oppose cooling by ventilation. During the day, trees reduce the mean radiative temperature but also the ventilation, i. e. the exchange of sensitive heat is restricted. At night, tree canopies additionally prevent cooling by outgoing radiation from the ground. On the one hand, the thermal effect of urban vegetation can be measured directly in the immediate vicinity. On the other hand, turbulent and advective heat flows are difficult to measure and have a long-distance effect. Here we apply the turbulence-resolving urban climate model PALM-4U to assess the strength and significance of individual processes.

The use of realistic vegetation models in micro-meteorological models is essential for simulations in the roughness range of the boundary layer. Previous comparisons between numerical simulations of turbulent flow, wind tunnel experiments and extensive field measurements showed fundamental improvement of simulation results for a forest stand compared to the use of unstructured vegetation models.

The presented work examines whether the mobile systems with laser scanners developed in recent years allow the effective extraction of such vegetation models.

Terrestrial laser scanner data were used to create vegetation models for 6 streets in Dresden with a resolution of 20 cm grid size. These data allows us to investigate the general question: How accurate do vegetation models need to be? Hereby, mobile measurements of radiation components, temperature, humidity and wind serve as reference data.

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Combining mesoscale and microscale modelling to get a complete chain of climatic models : a case study in Strasbourg city, France

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Abstract

Several meteorological models at multiple spatial scales are commonly used in urban climate studies. Both in terms of scales and approaches, each model category has its own advantages and drawbacks. Yet implementing a chain of models would combine their different benefits while overcoming their respective shortcomings. Hence, modelling the whole city while apprehending microclimate processes even at the street scale, would be achievable. Even if the first step of this chain, i.e. downscaling from global-regional to mesoscale, is already commonly applied, the combination of mesoscale and microscale modelling remains very limited. A methodology aiming to acquire such a complete climatic simulation sequence coupling meso and microscale modeling is proposed here. In addition to the global reanalysis of the CEPMMT, the mesoscale atmospheric model Meso NH coupled with the land surface scheme SURFEX, the thermo-radiative microclimate model LASER/F and the CFD microclimate model ENVI-Met are employed. Each of these models has been previously validated using meteorological measurements. The first results confirm the interest and workability of the developed procedure and highlight the specific contribution of the different models.

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Key psychological drivers for thermal comfort perception in humid subtropical outdoor spaces: The role of vegetation dynamics

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Abstract

Outdoor thermal discomfort can reduce usability and liveability in urban areas declining the health and well-being of citizens. Therefore, assessment of outdoor thermal comfort (OTC) is essential to design functional and viable outdoor spaces. Overall thermal comfort perception (TCP) of a user is governed by both objective (e.g. physical) and subjective influences (e.g. personal, physiological, behavioural and psychological). Scholarship, however, indicates under exploration of psychological influences (mood, experiences, expectations, choice and control etc.). In this study, we examine the key psychological drivers that affect outdoor TCP taking the case of five residential neighbourhoods of the north Indian city of Dehradun. A total of 468 participants were interviewed in the summer of 2019 using semi-structured questionnaires. As urban vegetation (UV) is a widely accepted measure of heat stress mitigation in urban areas, we also inquired about user preferences pertaining to spatial and parametric UV dynamics that have direct implications on objective and subjective thermal comfort. Our results indicate that contrary to the objective assessment where the neighbourhoods were subjected to extreme heat stress (>42oC PET), only 11% of the respondents felt highly uncomfortable. The momentary TCP of residents was influenced primarily by solar radiation followed by humidity indicating the need for maximising shade in outdoor spaces with proper wind channels. The long-term thermal perception was affected by the awareness related to decrease in greenery in the neighbourhood coupled with the concern on increase in temperature over the years. The richer neighbourhoods assigned higher importance to green space provisioning in comparison to the middle-income ones. In relation to the spatial and parametric characteristics of urban vegetation, psychological impacts rooted in the degree of naturalness, perceived control, visual and environmental stimulation became evident. In conclusion, perception studies can crucially support the holistic evaluation of thermal comfort for human well-being and desirable outdoor spaces.

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Biometeorology & health: Urban microclimate and comfort

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Implementation of high-resolution WRF-BEP+BEM modelling for Minsk, Belarus with different approaches to urban morphology representation: analysis of urban heat island and urban pollution island effects

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Abstract

In this study we present first results of our implementation of the WRF-BEP+BEM modelling system for Minsk with two different approaches to urban morphology representation: one involving the Local Climate Zones (LCZ) methodology and the other being based on direct input of urban parameters on the model grid. We combine satellite remote sensing data, centralized city planning databases and geoinformation systems (GIS) with Open Street Maps (OSM) vector data to build different descriptions of land use / land cover for Minsk urban territory and the surrounding region and to get both LCZ-based and alternative representation of buildings, streets and other urban parameters for the city. Our aim is to analyze the applicability of each approach to urban morphology representation with different levels of detail (500 m, 300 m and 100 m grids) in view of some characteristic features of Minsk – both unique and typical for former Eastern Bloc city planning. For that purpose we use different configurations of the WRF-BEP+BEM modelling system to perform a series of simulations involving various meteorological conditions to investigate manifestations of the Urban Heat Island (UHI) and Urban Pollution Island (UPI) effects in Minsk. Special emphasis is made on analysis of surface temperature parameters and near-surface atmospheric circulation, the latter being important for urban ventilation and atmospheric pollutants transport inside the urban area. For validation, we use observational data of surface temperature, wind fields and atmospheric pollution from ground-based measurements (including both regular observations and crowdsourced data from citizen weather stations and air quality monitoring) and satellite remote sensing for Minsk urban area and the surrounding region.

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Urban climate methods: Modelling

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Evaluation of wind flow over terrain for urban climate modelling of high-density neighborhoods

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Abstract

Several sophisticated CFD simulations with topographical treatments [1][2] have been developed for urban wind studies over the past years . They show that the presence of terrain affects the dynamics of air flow like the direction of pollution dispersion from industries [3]. However, multi-physics modelling of dense urban areas with topographical treatment have received limited attention. Since inclusion of terrain is likely to increase mesh count and complexity of the model, consequently increasing simulation costs, the evaluation of its significance on pedestrian wind flow is pertinent.

In this study, we investigate 1) the prevailing terrain modelling techniques for CFD simulations and their applications 2) significance of terrain in pedestrian wind flow and 3) computational resource requirement for 3D LES simulation of a high-density urban region modelled with surface topology.

Therefore, this work presents a CFD study of a neighborhood in Downtown Singapore using standard Smagorinsky LES turbulence model to calculate transient wind flows with and without the presence of natural terrain. Compared to studies in literature, we model the topography closer to the buildings with a buffer area in the computational domain. The test probes are distributed at various heights around buildings and street canopies. The effect of terrain is measured on wind speed and direction at these test probes.

Results from this work may be useful for CFD modelers to make informed choices on the inclusion of terrain when performing 3D LES simulation of a high-density urban area.

[1] E. Ng. “Revisit of prevailing practice guidelines and investigation of topographical treatment techniques in CFD-Based air ventilation assessments”

[2] B. Blocken et.al “CFD simulation of wind flow over natural complex terrain: Case study with validation by field measurements for Ria de Ferrol, Galicia, Spain”

[3] N. Erain, “Understanding the Effect of Surface Terrain on Pollution Transport around Gebeng Industrial Area”

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A Framework to Optimise the Impact of Green Infrastructure in Improving Socio-Environmental Vulnerability: A case study of Greater Glasgow

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Abstract

The aim of study is to investigate the socio-environmental vulnerability blended with the potential of GI in Glasgow to demonstrate how two aspects such as social and environmental aspects that often are treated separately in relation to green infrastructure can be combined

to scope a Vulnerability Assessment following the AR4 model (IPCC, 2007).

Based on an extensive literature review, a set of 16 indicators were used. The analysis was built by combining ArcGIS following the Multicriteria Decision Analysis (MCDA) model.

In support of the new Urban Agenda and SDGs, this approach incentives to be an addition to the climate change measures and strategies of Glasgow City Council and moreover counteract social inequities in support of sustainable cities and communities with inclusive and accessible green spaces for the most vulnerable.

As a result of combining these indicators, and prioritising decision-making, a Hotspot Analysis of prior interventions is produced to identify the most vulnerable zones with the highest potential for GI integration.

Further investigation was conducted through simulation software (ENVI-MET) to demonstrate and analyse the influence of GI on two different urban structures that fall under the high vulnerability/ mitigation potentials.

The results demonstrate that GI depending on the urban structure has the potential to provide Glasgow with the diverse socio-environmental benefits and ecosystem services essential in combatting climate change and archive climate justice while preserving biodiversity.

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Integrated assessments of urban climate : Urban climate and climate change

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Potential of WUDAPT as common language across various communities in supporting resilient and healthy urban planning – A review

Dr Yuan Shi ORCID iD[1], Dr Chao Ren[2], Dr Guangzhao Chen[2], Dr Ran Wang[3], Dr Meng Cai[4], Dr Yong Xu[5], Dr Yingsheng Zheng[5], Prof Edward Ng[4], Dr Jason Ching[6], Dr Sarav Arunachalam[6]

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Abstract

According to the United Nations Revision of World Urbanization Prospects, the world urban population has increased by approximately 4% from 2010 to 2020. There was an increase of nearly 800 million in the urban population in the past decade. It has been confirmed that the ten years from 2009 to 2019 are the warmest decade in the historical records. Climate change and surging urban populations pose enormous challenges for global urban sustainable development. How to plan and design more resilient cities and provide people with a livable living environment has become a high-priority concern of environmental scientists, climatologists, urban planners and other people from communities of academics and practitioners. In order to meet these challenges, methods and techniques from different communities including but not limited to climate modelling, geospatial data analysis, urban microenvironment monitoring, urban planning and design need to be integrated in a disciplinary way. Such an interdisciplinary process requires strong urban data support. Fortunately, the past decade has been a decade not only facing challenges but also offering opportunities. World Urban Database and Access Portal Tools (WUDAPT) has been developed as a universally consistent urban canopy layer methodology which not only enables intraurban, multi-scale model applications but also has a great potential to become a common language and platform across disciplines and communities. Following a three-stage framework consisting of database generation, impact assessment, and planning and design intervention, this poster presentation reviews and recaps some of the representative WUDAPT applications beyond the urban climatologists' community in the past decade and provides insights on how the WUDAPT and Local Climate Zone (LCZ) typology could be utilised by various communities in supporting resilient urban planning and design.

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Special Session: World Urban Database and Access Portal Tools (WUDAPT): World Urban Database and Access Portal Tools (WUDAPT)

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Mitigating Urban Warming with Earthen Materials: A Neighborhood scale microclimate study across multiple residential Local Climate Zones

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Abstract

As the global urban population grows exponentially, the need to construct more residential neighborhoods has become paramount more than ever. The ability to predict the impact of the rapidly expanding urban areas on the local climate is critical to the wellbeing and comfort of the society. This increasing building footprint reduces the amount of impervious and green spaces in cities, thus contributing to the overall warming of the urban environment, resulting in the “heat island (UHI)” phenomenon. However, the characteristics of building materials such as the hygrothermal properties have a huge impact on the dwelling insulation which in turn influences the need for energy-intensive indoor summertime cooling. Increasing summer air-conditioning demands release heat into the outdoor environment, and so the start of a vicious cycle.

In this study, we examine the potential of mitigating the UHI effects by leveraging on the high thermal mass properties of earthen materials for wall constructions. Such traditional materials have been shown to absorb excess heat, and so may buffer heat island effects whilst reducing overall dwelling energy demands. The impact of adopting these earthen materials on the immediate outdoor microclimate and human thermal comfort conditions is examined at the neighborhood scale using ENVI-met CFD simulation. Further, to understand the corresponding effect on neighborhood level changes in summertime heat after changing housing materials, the study analyzed multiple residential neighborhood types (compact, open and sparse low-rise) using the Local Climate Zones (LCZ) classification. In this contribution, we investigate the hypothetical scenario of replacing conventional cement materials with traditional earth-based alternatives in mitigating emerging UHI effects and show results across various residential neighborhoods. Ultimately, the findings will help modify construction practices and provide urban planning recommendations with the goal of ensuring sustainable buildings for future climate adaptation.

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Biometeorology & health: Urban microclimate and comfort

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The impact of COVID-19 confinement measures on the canopy urban heat island intensity of Ghent (Belgium)

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Abstract

In the context of the COVID-19 outbreak, a strict lockdown was ordered by Belgian authorities from 18/03/2020 till 04/05/2020. This led to a limitation of industrial production, human activities, and transport use where only essential motorized transport was permitted. This research is an attempt to study the impact of these measures on the canopy layer urban heat island intensity in the city of Ghent. We used the high-accuracy observational MOCCA (MOnitoring the City's Climate and Atmosphere) network. The network consists of six weather stations in the Ghent region and provides a database of hourly observations including 2m temperature at six locations (including dense urban, industrial and suburban). Only UHI days are selected for both the confinement period in 2020 and similar periods in the reference years 2017, 2018, 2019, and 2021. UHI days are defined as days where the conditions for a strong UHII are fulfilled. Results indicate a lower UHI intensity during the late afternoon and the morning for 2020 compared to the reference years for the dense, industrial, and suburban sites. A statistically significant difference was found at 8h and 18h for the dense urban site. To evaluate the hypothesis that the significant difference in UHII between 2020 and reference years is due to the anthropogenic heat of traffic, 5 UHI days in the period of April 2020 are simulated with the ALARO-surfex/Teb atmospheric model. Two configurations were run with a spatial resolution of 1.3 km one where the anthropogenic heat was set to its default value and one where it was set to zero. The highest difference in UHII between both runs can be seen for dense urban station with a statistical significance difference at 9,15 and 16h. Both the observations and model outputs show a significant difference in UHII during the rush hours.

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Special Session: COVID/pandemic lock-down: Impact of COVID/pandemic lock-down measures on Urban Climate, Air Quality, and Human Life

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Significance of using building height and imperviousness information in improving LCZ classification

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Abstract

Local Climate Zone (LCZ) classification is already widely used in urban studies, but the current WUDAPT classification approach does not incorporate crucial urban auxiliary GIS data on building height and imperviousness information, which could significantly improve urban-type LCZ classification accuracy. Using Austin as an example, building height information enhances the accuracy of the high- and mid-rise classes, whereas imperviousness information improves the low-rise classes. We tested with two different building heights and imperviousness products, and the results were consistent. The significance of the urban auxiliary information was further tested with the single-pass forward permutation test. It reveals that the categorization accuracy is dominated by both urban features, followed by thermal infrared bands. Despite the fact that the building height information may not available to every city, the imperviousness products used in this study were available either globally or in the US. As a result, the current WUDAPT classification framework can be easily improved.

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Weighting Mechanics and the Spatial Pattern of Composite Metrics of Heat Vulnerability in Atlanta, Georgia, USA

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Abstract

This study constructs two biophysical metrics; one based on Land Surface Temperatures (LST) and an integrated spectral index. The latter is an aggregate of the Normalized Difference Vegetation Index (NDVI), Normalized Difference Bareness Index (NDBaI), Normalized Difference Water Index (NDWI), and Normalized Difference Built-up Index (NDBI). The goal is to determine how disparate weighting techniques, data transformation approaches, and spatial visualization pathways influence the computation of composite heat metrics. Using composite images made of aggregated images from late May to Early September within Google Earth Engine, we generated four composites by combining biophysical metrics with SoVI using equal and Eigen-based weightings informed by Principal Component Analysis (PCA). We compared equal interval classification, global and local Moran's as pathways for spatial visualization of hotspots. We utilized several data transformation techniques in a Geographic Information System (GIS), including rescaling, reclassification, zonal statistics, and spatial weighting. Mann Kendall and Sen's Slope detected and quantified monotonic trends in each spectral index. The results show that the LST biophysical metric and its composites indicate increased heat susceptibility over time, with disproportionately exposed core metro counties. The integrated spectral index and its proxies showed reduced vulnerability hence not a good proxy for LST. At the same time, the Mann Kendall and Sen's Slope found persistent increases in NDVI and NDWI and decreases in NDBI and NDBaI. However, opposite trends were evident in core city counties. The LST-based composites and spectral indices-based composites varied in the spatial-temporal distribution of hotspots. Disparate weighting mechanics, data transformation techniques, and visualization alternatives influence the magnitude and spatial-temporal distribution of heat hotspots.

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Urban climate policy: Knowledge transfer of urban climate

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Atmospheric Conditions in and around Urban Area during Pre-monsoon Season over Eastern India

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Abstract

The urban land use land cover is known to modify the temperature and moisture characteristics from the surface to the lower atmosphere, which are some of the crucial forcings for severe convective events. The study focuses on the signature of urbanization on the temperature, moisture, and precipitable water vapor during the pre-monsoon season over the eastern parts of India. The Moderate Resolution Imaging Spectroradiometer (MODIS) 500-925 hPa atmospheric profiles during 2001-2021 have been considered. The study covers six different cities across eastern India, i.e., Kolkata, Ranchi, Patna, Bhubaneswar-Cuttack, Visakhapatnam, and Hyderabad. These cities have different characteristics in terms of size, population density, vegetation cover, distance from coastline, etc., and thus, have different impacts on the atmosphere.

Kolkata, one of the biggest cities considered in the study, shows clear signatures of urban heat island (UHI) with higher mean temperatures of >0.5℃ in the day and >0.15℃ at night in most years compared to the surroundings. A negative anomaly of mixing ratio (~0.2-0.3 g kg^{-1}) and precipitable water vapor (>1mm) are also observed over the city. Similar atmospheric conditions are also observed over Hyderabad. On the contrary, the coastal city of Visakhapatnam does not exhibit such patterns, which could be attributed to its proximity to the Bay of Bengal. Similarly, the presence of the Ganga river to the north is evident for Patna city, as negative anomalies of temperature (>0.2℃) are observed towards the north. In contrast, positive anomalies of temperature (>0.15℃) are observed over the city. Bhubaneswar contains large amounts of vegetation, and the effects of UHI are largely reduced. However, Cuttack, ~10 km from Bhubaneswar, exhibits positive temperature anomalies and negative anomalies of moisture. Thus this study highlights the importance of different land use land covers in a city in the context of the atmospheric modifications related to urbanization.

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Analysing Outdoor Thermal Comfort due to proximity to water surface in Tropical Humid Climate - Case Study in Kolkata Municipal Area

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Abstract

This study shows the importance of proximity to waterbodies in creating a pleasant outdoor thermal comfort conditions. The index used for measuring and evaluating outdoor thermal comfort is Physiological Equivalent Temperature (PET). The mean radiant temperature is calculated using the values of Globe temperature, air temperature, wind speed and global radiation and is an important parameter in calculation of PET . Primary data is used to generate PET values in the EnviMet software. Thermal Perception, Thermal Sensation, Thermal Acceptability and Thermal Tolerance has been recorded using Questionaire Schedule. Landcover of selected stations at neighbourhood scale, were measured using Plan Area Fraction (Oke,2017). Unsupervised classification of landcover, NDVI, NDWI, NDBI was also conducted using Arc-Gis to understand the surface characteristics responsible for contribution to thermal load or dynamic potential. Thermal Load refers to heat storage in urban areas and Dynamic Potential refers to thermal contributed by ventilation and wind circulation [10-13] . The two stations show different landcover with Station 1 having 67.6% built surface and 21.5% impermeable surface. Station 2 has lesser share in built and impermeable surface , the values for the same category is 1.5% and 49.8% respectively. Station 1 being located 2 km from the lake area of south Kolkata, West Bengal, recieves the lake breeze in the evening. Station 2 has 45.9% of water surface and the point of observation is in proximity to water body. In station 2, pedestrian are satisfied and comfortable throughout the day. Station 1 shows comfort conditions only in the evening during breeze from lake area. In this study, the authors have tried to draw comparison of the outdoor thermal conditions of the two stations with help of simulation on EnviMET and thermal sensation study.

Keywords

Outdoor Thermal Comfort, PET, Plan Area Fraction ,Thermal Perception,Thermal sensation.

Session Themes

Biometeorology & health: Urban microclimate and comfort

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Using the Austin Heat Mapping for Active Learning and Community Resilience Partnerships

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Abstract

This presentation will provide a brief summary of three urban heat and community resiliency partnership activities underway in Austin.

Cities are experiencing intense heat and associated health impacts under rapid urbanization and warming climate. Satellite data can be used to study the Surface UHI (SUHI) as they offer a large geographic coverage across different locales. We map the Austin, TX heat island at different spatio-temporal scales using Landsat, MODIS, and EcoSTRESS products. We also quantify the SUHI using the Local Climate Zone (LCZ) framework. SUHI maps generated from this work are intended to be usable by local stakeholders to be used to generate targeted and effective local UHI mitigation policy.

As one of the hottest cities in the US, stakeholders in Austin face the challenge of advancing equitable/ efficient heat mitigation strategies. As a partnership between local communities, city government, and academia, this study seeks to docket Austin’s current strategies and successful methods from cities of similar climates. This information will form the basis of an evaluative case study that presents viable models of heat mitigation infrastructure. These models will be shaped by community identified needs, and will ultimately serve as implementable strategies for the city government.

Also, while UHI has been extensively researched, its underground counterpart, the subsurface urban heat island (SubsUHI), is much less understood. SubsUHI has variable impacts which must be balanced in urban design. This study aims to motivate the development of subsurface temperature datasets and analysis to be used by city planners. The definition and causes of SubsUHI, previous methods of study used to quantify it, and its resource management implications, especially geothermal energy potential, will be explored to provide the importance of SubsUHI study.

These studies exemplify the different disciplines that must be brought together to translate urban climate data into usable policy.

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Integrated assessments of urban climate : Urban climate and climate change

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Smaller and medium sized cities (SMSC) should also be climate informed, resilient and sustainable - A scoping review on research foci among SMSC globally

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Abstract

The rise in population and associated infrastructure development drives the growth of all cities, regardless of size, shape, or form. Small and medium-sized cities (SMSC) have grown at a faster rate than major cities over the last decade. According to the 2021 Intergovernmental Panel on Climate Change (IPCC) report, population movement and growth will continue to be concentrated in SMSC, especially in developing countries. As extreme weather events increase, these municipalities with lower adaptive capacity are ill-equipped to effectively respond. Much of the literature has focused on the growth and dynamics of large and mega cities, and SMSC have not received the same level of attention. In light of the climate crisis and SMSC growth projections, it is necessary to analyze the level of scientific research and capacity building in SMSC. A scoping review was conducted in this work utilizing three search engines (Web of Science, Academic Premier Search, and Google Search) to discover SMSC research on three primary topics: sustainability, migration, and climate resiliency. Using a Boolean operator, 6,493 SMSC papers published since 1901 were discovered, including 522 papers related to sustainability, 433 to migration, and 208 to climate resiliency. Titles and abstracts were examined for article selection, resulting in 25 sustainability, 61 migration, and 57 climate resiliency papers on SMSC. A thorough assessment of the selected articles highlighted current gaps in SMSC readiness and local resiliency, which is critical in the aftermath of climate change. The future SMSC research should focus on locational and topical gaps found in existing body of work as highlighted in the perspective scoping review conclusions.

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Climate Action Plans for US Cities – A Textual Content Analysis and Evaluation

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Abstract

Climate change leads to havoc and extreme weather events such as storms, floods, heat waves, drought, and wildfire by affecting the variances in the intensity, duration, frequency and spatial extent of these events globally. These extreme events and disasters are contingent on vulnerability components such as geographic, physical and social conditions. In attempts to adapt climate change effects, planning is a fundamental strategy for sustainable development and policy making implications. US cities are addressing climate challenges at the local and regional scales by implementing Climate Action Plans (CAPs), a planning framework that gained a momentum in the mid-1990s. In this research, we aim to assess the current state of climate planning and carry out textual content analysis of CAPs for 216 cities in the United States. Based on the population size, these cities are organized into small, medium, and large cities/metro regions. CAPs have also been stratified by time and climate regions. The plans are evaluated for their emphasis on short term and long-term goals, disaster preparedness, resiliency goals and broader adaptation measures. Some of the research questions investigated are: What emphasis of climate plans is on greenhouse gas mitigation, urban heat, and flooding threats? How do plans differ spatially (regions of US), temporally (older versus newer), and across city size? How do climate plans address health, economic, and environmental benefits? Preliminary assessments show that there is a greater emphasis on reducing emissions, which is unsurprising as greenhouse gases (accounting and reduction) are considered the cornerstone of climate planning. Many small medium cities do not engage sufficiently in climate planning, and there are missed opportunities for cities to be resilient towards heat and flood risks. This analysis explores the breadth and spread of climate action planning in the US cities and provides key takeaways for planners and policymakers.

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Urban climate policy: Planning and Governance

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Spatial variation of excess mortality during the heat wave of 2018 in Stockholm

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Abstract

The record hot summer of 2018 and IPCC projections for Northern Europe have raised the awareness of the impacts of heat waves on human health, even at high latitude cities. Epidemiological models tend to underestimate the mortality in Stockholm during the 2018 heatwave. One of the possible explanations is that the mortality analysis usually relies on data from a single weather station. The underlying assumption is that the spatial distribution of temperature is constant over time and that it represents the different urban microclimates that are present.

Our method is based on the dynamical downscaling with the weather forecast modelling system HARMONIE-AROME down to a spatial resolution of 1 km. Model data is correlated with population and mortality data aiming at a better understanding of the urban heat island impact on increased heat-related mortality.

The comparison of model results against local observations shows that the model captures the dynamics of the intra-urban air temperature gradients with good performance skills. Moreover, it’s capable of revealing the spatial and temporal features of the heat and cold islands in high detail.

The model results reveal that in 2018 the warmer air extended over an area larger than usual. Our results show that the difference in spatial distribution of temperature during the 2018 heatwave increased the exposure to temperatures above 21.7°C and 25°C by, respectively, 9% and 13.7%. The death toll during the heatwave was greater in Stockholm compared to neighbouring counties. The excess mortality did not follow the pattern from the heatwave of 2014 and 2010. The extension of the urban heat island might be a contributing factor.

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Urban climate processes: Extreme weather and disasters in the urban environment

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Introducing Urban Digital Twins (UrbDT)

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Abstract

In recent years, the concept of Digital Twins (DT) has evolved from a prototype of a hydromechanic system to a simulator within global climate system. Here we introduce the idea of Urban Digital Twins (UrbDTs) to advance urban climate research and application.

The UrbDT is a combination of social/human and geophysical/engineering interfaces. Each of these components can be modeled at their relevant scale for the dynamical system interactions. Elements associated with downscaling using simplified AI/ML-based emulators, and development of data from physics-based models are some of the key next steps.

A DT is a computational representation of a physical object which is linked to real time data inputs. Such technologies can include complex and large-sized items such as buildings, factories and urban elements, up to entire cities. Thus the DT technology has moved beyond manufacturing and simple information modeling into static or dynamic urban big data analytics. These big data are generated and driven by populations and societal processes. In the UrbDT setup, the creation of multiscale data products, and a bi-directional communication link among physical, cyber, and social infrastructure systems is a significant distinguishing feature. A continual flow of infrastructure-based informatics and data and their related life cycle information is what makes the UrbDT a dynamic and evolving entity, not merely a high-fidelity virtual copy. To achieve this goal, a better understanding of how humans make decisions and social organizations are key factors in understanding such mechanisms.

We demonstrate a new approach for the UrbDT concept for enhancing community resilience in coastal regions, one in which the spatiotemporal dynamics of local vulnerabilities and recoveries are integrated into an analytics platform fusing datasets from various sources including crowd sources and other agencies. This creates exciting opportunities for simulating ‘what-if scenarios’ to inform policy development and decision-making.

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Urban climate methods: Urban climate informatics