

Introduction to the Special Issue on commemorating Decadal Anniversary of the World Urban Database and Access Portal Tool (WUDAPT)

In honour of Jason Ching

This special issue was organised by Jason Ching to showcase the potential value of the World Urban Database and Access Portal Tools (WUDAPT) project to support urban climate studies, especially in relation of air quality. Unfortunately, since Jason announced the call for papers, he passed suddenly in September last year following the International Conference on Urban Climates in Sydney, Australia. At that conference on 1st September 2023 Jason Ching received the Luke Howard Award (Figure 1) for his lifetime contributions to urban climate science. It was a fitting tribute to his research work of over 50 years on the planetary boundary layer, turbulence and landscape heterogeneity at small scales, and air quality and mesoscale modelling. Jason will be remembered as a humble scientist with a clear vision for urban climate science (Mills et al., 2023). Part of his shared vision was the creation of an urban information infrastructure to support climate modelling in cities; this was realised in the WUDAPT project which he co-founded and led for many years. This is the second WUDAPT Special Issue published by the Urban Climate journal, the first one (Mills et al., 2022) was also initiated by Jason and co-edited by him. This special issue represents a major stage in WUDAPT development with a focus on the value of its methods for urban climate, weather and air quality studies.

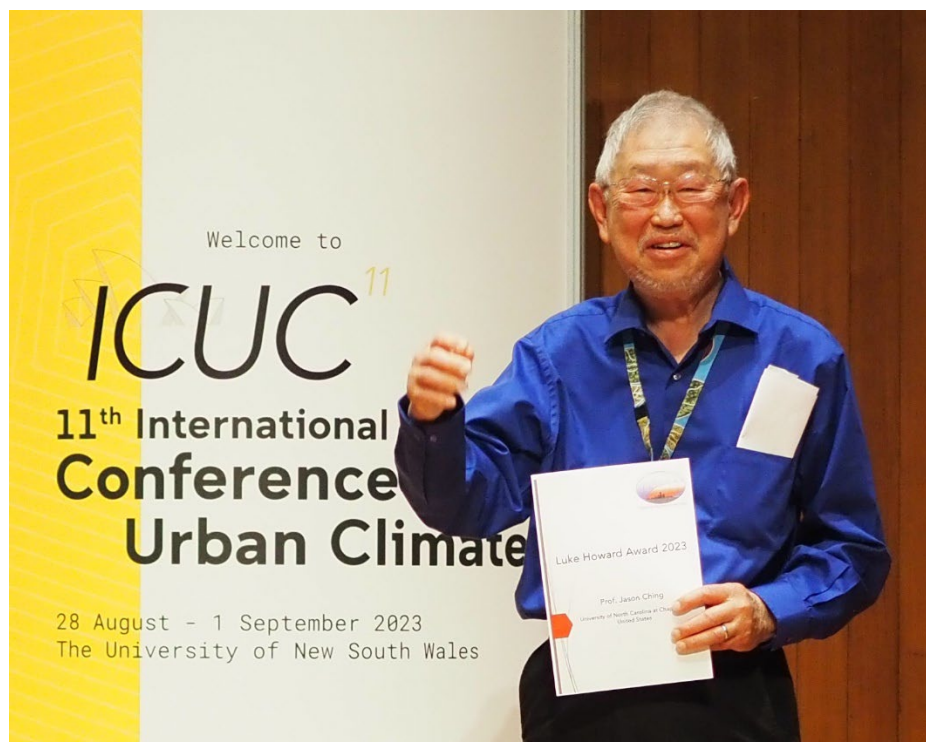


Figure 1. Dr. Jason Ching, receiving the Luke Howard Award on the International Conference on Urban Climates in Sydney on September 1, 2023, for his lifetime contributions to urban climate science.

Much of Jason's career was as a meteorologist working with the USA EPA from the 1970's until 2012. Over his forty-year career, he worked on many of the most significant regional air quality projects in the USA, including the Regional Air Pollution Study (RAPS), and the development of the Community Multiscale Air Quality model (CMAQ) (Byun and Ching, 1999). However, in the early 70's the RAPS and METROMEX experiments shared St. Louis as a study area and Jason was able to indulge his interest on

key topics such as the heterogeneity of the urban landscape, the development of the urban boundary layer and the storage of heat in the substrate. He returned to urban issues in the 2000's when the atmospheric models had evolved to the point where detailed information on urban landscapes (urban canopy parameters or UCPs) was needed (see his overview in Ching, 2013). Jason initiated the National Urban Database and Access Portal Tools (NUDAPT) project to provide UCPs to support the evolution of the next generation of models (Ching et al., 2009). Critically, the concept incorporates both a database created to support scientific work and a set of tools that allow these data to be incorporated into applications. Initially the NUDAPT concept was realised for several USA cities. In 2007 Jason presented the NUDAPT methodology on the European COST Action 728 on Meso-Meteorology and Air Pollution. This approach extended outside the USA and started to be implemented and further developed for European cities within FUMAPEX, MEGAPOLI and other international projects (Baklanov et al., 2009).

In his retirement speech to the EPA more than a decade ago, Jason outlined his perspective and personal mantra:

- To gain and to continue improving our understanding of atmospheric processes, and concurrently to build analogs (models) of these process that can best “mimic” them, yielding tools that can effectively predict weather, air quality and climate.
- There is real joy and meaning when engaged in the active pursuit of these endeavors. Recognizing such opportunities, and meeting and overcoming their challenges are my drivers.

WUDAPT became his post-retirement project and its fits this scientific philosophy perfectly. It originated at a conference on Urban Climatology for Tropical and Sub-Tropical Regions in Hong Kong (2011) (Figure 2); it was created to fulfil a number of objectives (Ching et al., 2018) - first, to gather useful information on cities that could be employed by climate scientists worldwide; second, to provide the tools and framework needed to employ these data to undertake scientific research in broader communities of urban climate, hydrometeorology and air pollution; third, to contribute to the formation of an international community of scholars interested in contributing to the development of an urban science that was founded on the principles of co-production of knowledge and sharing its benefits.



Figure 2. The launch of the WUDAPT global project at the Chinese University of Hong Kong in 2016, hosted by Prof. Edward Ng. Jason is next to the 'G' in Global.

WUDAPT has adopted a hierarchical approach to the acquisition of data and employed Local Climate Zone (LCZ) typology, which categorises urban landscapes into 17 neighbourhood types, 10 of which are urban (Stewart and Oke, 2012). Each LCZ type is associated with a set of variables with a range of values; these parameters have international classification scheme, which for the first time enables cross-disciplinary and cross-region conversation between meteorologists, environmental scientists and urbanists. Each neighbourhood is identified by a set of characteristics (built cover, impervious fraction, mean building height, etc.) so that a map of LCZ types across a city is also a map of UCPs. The methodology to apply this approach has developed considerably since WUDAPT started; as examples, the urban climate team based in Bochum (Germany) created the LCZ generator, which allows anyone to generate a LCZ map for a selected urban domain (Demuzere et al., 2021) and the satellite-based methods they developed have generated the first global LCZ map (Demuzere et al., 2021). Moreover, the value of LCZ generated UCPs, via WUDAPT, has been proven in modelling studies (e.g. Alexander et al., 2015 and Brousse et al., 2006) and is now incorporated into the WRF model. The World Meteorological Organization is considering the use of WUDAPT as a means toward addressing its new urban services mandates, for Integrated Urban Hydrometeorological, Climate and Environmental Services (WMO, 2019, 2023) and for Chemical Weather/Air Quality Forecasting (WMO, 2020). The IPCC Cities and Climate Change Science Conference in Edmonton, Canada (2018) in their analysis of upscaling urban data science for global climate solutions consider WUDAPT as one of the mainstreaming and harmonizing tools for these issues (Creutzig et al., 2019).

This volume is comprised of nine papers that examine issues that were dear to Jason's vision for the development of an urban climate science. The subject of these papers include:

- A survey of the methods for LCZ mapping and the application of these data for climate. Wang et al. (2024) use statistical and metadata analysis methods are used to summarize and analyze a sample of LCZ-related papers published since 2012 and provide a pathway for future urban climate research.
- Improved methods for deriving maps of the urban landscape suited for climate research. Vaidya et al. (2024) provide methods for deriving LCZ maps to cope with extreme spatial heterogeneity in some cities, which the standard WUDAPT method does resolve. Similarly, Du et al. (2024) develop an expanded LCZ scheme to deal with diverse urban landscapes: the new scheme introduces four novel LCZ types and modifies and subdivides the standard LCZ types to describe such landscapes.
- Applying WUDAPT/LCZ data to study urban climate effects. Žgela et al (2024) reports on the relationship between LCZ and surface urban heat island in nine Croatian cities. Liu et al. (2024) develop a framework for heat stress resilience assessment using the universal thermal climate index, the WRF model, and LCZs. Smithson and Adams (2024) use LCZs to run urbanised WRF to establish a baseline climate for a large city; once evaluated, the model is used to test three scenarios representing multi-decade urban growth using associated LCZ transformations. Zhang et al. (2024) undertook an examination of derived LCZ properties (e.g, NDVI, population density, and road nuclear density) on LST in selected cities representative of different climate types.
- Developing new methods to derive parameters for modelling urban climates. Ao et al (2024) evaluates urban canopy schemes and UCPs in a high-resolution regional operational model on meteorological fields using dense automated weather stations. Finally, Sun et al (2024) used multiple data sources to create a detailed geography of urban CO₂ emissions that could be integrated with WRF-Chem and used to derive column averaged values over cities.

The WUDAPT project is still developing. Its plans are to increase the range of UCPs and improve their accuracy and precision. The LCZ scheme used by WUDAPT (Level 0) had the great advantage that it could be applied consistently at urban scales for cities worldwide; moreover, the techniques developed for mapping LCZs could avail of globally available satellite databases. The next steps (WUDAPT Levels 1 and 2) need an equivalent approach that can capture intra-urban variations in aspects of urban form such as building dimensions, material composition data and energy usage. Let us hope that the second decade of WUDAPT will be as successful as the first and that Jason's vision for an atmospheric modelling infrastructure that can support urban climate, weather and environment studies globally is realised.

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| 1 | Mapping local climate zones and applications at the global scale: A systematic review of the last decade of progress and trend. Wang, Wang, Ren, Chen, Mills and Ching. |
| 2 | Classifying heterogeneous urban form into local climate zones using supervised learning and greedy clustering incorporating Landsat dataset. Vaidya, Keskar and Kotharkar. |
| 3 | Development of an expanded local climate zone scheme to accommodate diversified urban morphological evolution: A case study of Shanghai, China Du, Kuang, Chen, Ye, Li and Shi |
| 4 | Linking land surface temperature and local climate zones in nine Croatian cities. Žgela, Herceg-Bulić, Luzok and Jureša. |
| 5 | Multifactorial influences on land surface temperature within local climate zones of typical global cities. Zhang, Zhou, Yuan, Wang and Wei. |
| 6 | Heat stress resilience assessment of urban form from physical space dimension: A case study of Guangdong-Hong Kong-Macao Greater Bay Area Liu, Wang, Chen and Wang |
| 7 | Use of LCZs with Urban Canopy Modeling to Evaluate Urban Growth Effects on Meteorological Conditions in the Salt Lake Valley. Smithson and Adams |
| 8 | Impact of urban canopy physics and detailed urban canopy parameters on high-resolution simulation over two large urban agglomerations in China. Ao, Huang, Zhang, Li and Sun. |
| 9 | Improving urban CO2 spatial distribution modelling using multi-source data. Sun, Wang, Ye, Wu, Shi, Li, An and Li. |