American Meteorological Society

# 5C.6: Urban Climatic Analysis for Heat Stress Mitigation in French Cities: A Case Study for Toulouse

**Tuesday, August 07, 2018**
**02:45 PM - 03:00 PM**
*City College of New York - SH - 95*

The adverse impacts of urban heat islands (UHIs) created by the compact built environment in French cities have been particularly evident during the 2003 heatwave (Cadot and Spria, 2006). There was a call for heatwave risk prevention to be put into action through climate-informed town planning and local mitigation strategies (Poumadère et al., 2005). Therefore, the French national MApUCE project aims to fill this gap, using urban climatic map (UCMap) as an information and evaluation tool to give a spatial representation of local climate characteristics and their corresponding planning recommendations. Being the fourth largest city agglomeration in France, Toulouse Metropolitan Region has been chosen for case study due to its strong urban sprawl (Pumain, 2004) and higher exposure to warming due to its southern and continental location (Mithieux, 2015).

According to the *WHO EuroHEAT project*, French cities suffered prolonged heat stress due to intense solar exposure and poor air ventilation during heatwaves. High death tolls could also be attributed to the elevated temperature in the late afternoon and nighttime caused by the inefficient heat release from building materials in compact street canyons (Pigeon, 2007). Unlike the conventional UCMap approach using a single weather condition (Ng and Ren, 2015), it is necessary to examine various time periods of a day during both typical and extreme summer conditions for Toulouse.

This study aims to develop an UCMap for Toulouse Metropolitan Region based on local climate zone (LCZ) classifications (Stewart and Oke, 2012) and formulate corresponding climatic-sensitive design strategies for heat stress mitigation. First, information on the geography and building morphology, as well as the Toulouse LCZ map (Hidalgo et al., submitted manuscript) are extracted from the MApUCE urban database (Bocher et al., 2018). Secondly, simulated hourly meteorological data, including air and radiant temperatures, at 2m above ground and a horizontal resolution of 250m from the MesoNH-SURFEX model are used for the climatic analysis. To provide a multi-scenario understanding of the thermal conditions, the typical and extreme summer conditions are then selected as 10 warm and dry days with light northwesterly winds (Hidalgo et al., 2014) in July 2004 and 12 days during the heatwave in August 2003, respectively. These data are further averaged over three selected time periods to capture features of the dynamic thermal environment, i.e. early afternoon (13-16h) when radiant temperatures are the highest, late afternoon (17-20h) when air temperatures are the highest, and nighttime (03-06h). Heat stress intensities are reflected by the calculated universal thermal climate index (UTCI).

Under typical summer conditions, results show strong heat stress (UTCI>32°C) in the city centre and the western side of River Garonne in the early afternoon due to high exposure to intense solar heat in areas dominated by compact low-rise buildings (LCZ 3). At night, a pronounced UHI effect of up to 3°C between the city centre and its outskirts is observed. During heat wave conditions, very strong heat stress (UTCI>38°C) is found over the whole Metropolitan Region. Strong heat stress remains until late afternoon, except for areas with trees (LCZ A,B) and water (LCZ G), due to prolonged radiation in the day and slow heat release from building materials. Persistently high air temperatures also led to heat accumulation in the densely built urban areas (LCZ 1-4, 8), resulting in temperatures up to 28˚C at night. Finally, areas are reclassified from 14 LCZs into seven climatopes, namely “Compact Settings” (LCZ 1-3), “Open Settings” (LCZ 4-6), “Large Low-rise” (LCZ 8,10), “Sparsely Built” (LCZ 9), “Trees” (LCZ A,B), “Grass/Shrubs” (LCZ D,E) and “Water Bodies” (LCZ G), based on their dynamic thermal characteristics (see attached figure). With an integrated understanding of the local climate, built environment, and socio-political factors in Toulouse, appropriate mitigation actions are then recommended for each climatope. In particular, due to the limited air movement during both typical and heatwave conditions, it is imperative to prevent building heat storage and reduce anthropogenic heat emissions for “Compact Settings’’ areas, while areas with “Trees” and “Water Bodies” should be preserved and enhanced as effective cooling resources.

This study presents a pioneering approach for developing the UCMap for Toulouse, which could serve as an exemplary reference for city planners and policy makers of other French cities to undertake climatic-sensitive planning and formulate heat stress mitigation strategies. The multi-scenario and dynamic thermal environment analysis would also be helpful for increasing the preparedness and resilience of Toulouse in face of future warming trends and more frequent heat wave occurrences.

Acknowledgement

The study is supported by The Vice-Chancellor's Discretionary Fund of The Chinese University of Hong Kong.

References

Bocher E, Petit G, Bernard J, et al., 2017. A geoprocessing framework to compute urban indicators: The MApUCE tools chain. *Urban Climate*, accepted manuscript.

Cadot E, Spira A, 2006. Surmortality related to the August 2003 heatwave: A contextual risk factors analysis in Paris, France. *Epidemiology* 17(6) Suppl: S163.

Hidalgo J, Dumas G, Masson V, et al., 2017. Comparison between Local Climate Zones maps derived from administrative datasets and satellite observations. *Urban Climate*, submitted manuscript.

Hidalgo J, Masson V, Baehr C, 2014. From daily climatic scenarios to hourly atmospheric forcing fields to force soil-vegetation-atmosphere transfer models. *Frontiers in Environmental Science* 2: 40.

Houet T, Pigeon G, 2011. Mapping urban climate zones and quantifying climate behaviors–an application on Toulouse urban area (France). *Environmental Pollution* 159(8): 2180-2192.

Mithieux C, 2015. *Le profil climatique de Toulouse Métropole*. Météo France. Version 0.7 - Date: 14/08/15.

Ng E, Ren C, 2015. *The urban climatic map: A methodology for sustainable urban planning.* Routledge, UK.

Pigeon G, 2007. *Les échanges surface-atmosphère en zone urbaine-projets CLU-ESCOMPTE et CAPITOUL.* Océan, Atmosphère. Université Paul Sabatier-Toulouse III.

Poumadere M, Mays C, Le Mer S, et al., 2005. The 2003 heat wave in France: Dangerous climate change here and now. *Risk Analysis* 25(6): 1483-1494.

Pumain D, 2004. Urban sprawl: Is there a French case? In HW Richardson, CC Bae (Eds.), *Urban sprawl in Western Europe and the United States*. Ashgate, England.

Stewart ID, Oke TR, 2012. Local climate zones for urban temperature studies. *Bulletin of the American Meteorological Society* 93(12): 1879-1900.

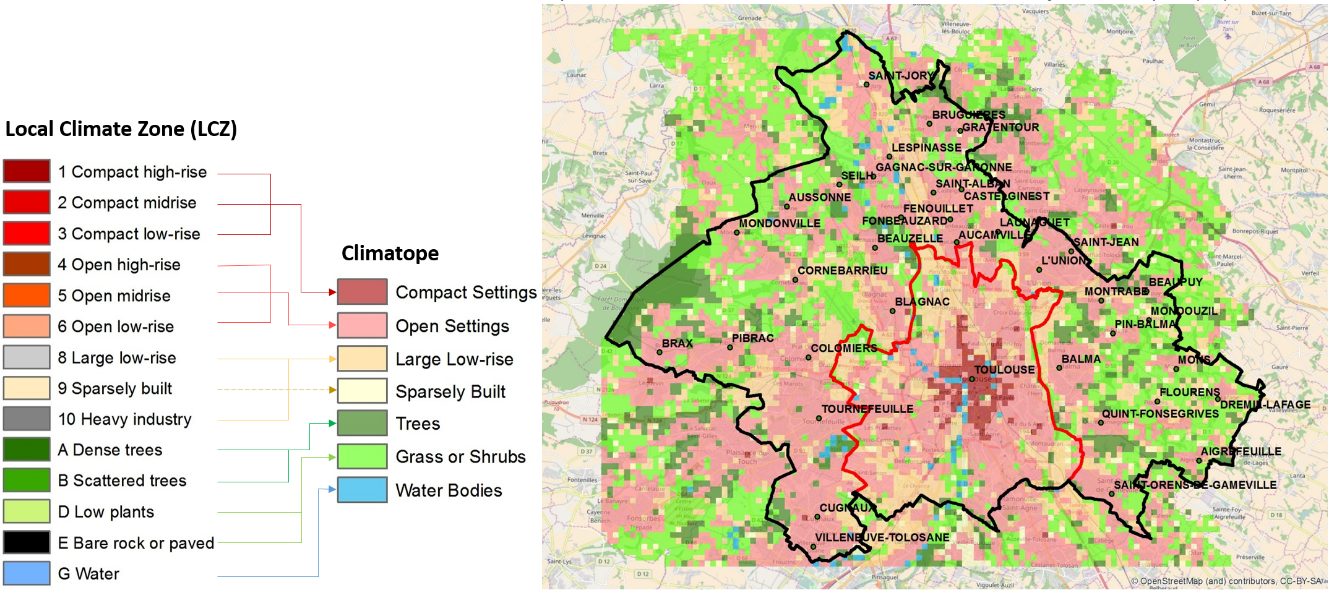


Figure 1 Urban climatic map for Toulouse Metropolitan Region based on the dynamic thermal characteristics of local climate zones.


## Authors

Kevin Ka-Lun Lau

Julia Hidalgo

Chao Ren

Robert Schoetter

**Yu Ting Kwok**

*Chinese Univ. of Hong Kong*

Valéry Masson

Xuyi Zhang

Xinwei Li


**ICUC_draft3.pdf**

*PDF File Upload (for Poster or Oral)*

Find Similar

## View Related Events

**Day:** Tuesday, August 07, 2018