EGU24-4289, updated on 14 Jan 2025
https://doi.org/10.5194/egusphere-egu24-4289
EGU General Assembly 2024

Modelling of urban lake breeze circulation: the implications on urban heat island mitigation

Qilong Zhong[1], Jiyun Song[1,2], Xiaoxue Wang[3], and Yuguo Li[1]
[1]Department of Mechanical Engineering, The University of Hong Kong, Hong Kong SAR, China
[2]State Key Laboratory of Water Resources Engineering and Management, Wuhan University, Wuhan 430072, China
[3]School of Information and Communication, Shenzhen Institute of Information Technology, Shenzhen, 518172, China

Recent years have seen more intense and frequent heatwaves across the globe. Urban overheating phenomenon induced by global warming and urban heat island (UHI) effect has adverse impact on human health. In particular, compact high-rise cities witnessed worsened wind environment, exacerbating the UHI phenomenon. Blue space such as urban lakes may help mitigate the UHI effect and improve citizens' living environment. Under weak synoptic wind conditions, the temperature difference between built-up areas and lakes can induce wind circulation, known as lake-breeze circulation (LBC). The LBC system can transport cool and fresh air from lake surfaces into built-up areas, reducing urban air temperature and improving urban wind environment, while increasing urban air humidity. In this study, we developed a multi-scale water-energy coupled CFD model to simulate the transport processes of heat and moisture between lake surfaces and built-up areas within the urban boundary layer. The model adopted a porous turbulence model to simulate the entire urban canopy layer, a lake evaporation model and a species transport model to simulate lake dynamics, and a coordinate transformation method to simulate the effect of the background atmosphere. The model features the capability of resolving dynamics of atmospheric temperature, humidity, and wind at both street canyon scale (1 m) and city scale (50 km) with relatively low computational costs. Based on this model, we conducted sensitivity analysis to investigate the impact of urban parameters (e.g., city scale, building height and density, anthropogenic activities) and lake parameters (e.g., lake scale and lake surface temperature) on the spatial variation of temperature, humidity, wind, and thermal comfort index. Our results can provide significant references for urban planning and city design for sake of UHI mitigation.