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The Implementation of the BEP+BEM Offline Parameterization Scheme: Exploring Urban Dynamics through Climatic Projections

Gianluca Pappaccogli[1], Andrea Zonato[2], Alberto Martilli[3], Riccardo Buccolieri[1], and Piero Lionello[1]
[1]Dipartimento di Scienze e Tecnologie Biologiche ed Ambientali, University of Salento, Lecce, Italy
[2]Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands
[3]Atmospheric Modelling Unit, Environmental Department, CIEMAT, Madrid, Spain

As climate change continues to exert an impact on urban areas, the comprehension of its effects on the urban environment becomes crucial for sustainable urban planning. This study presents a novel approach employing the Building Effect Parameterization (BEP) coupled with a Building Energy Model (BEM) in an offline configuration to simulate urban climates. The multi-layer BEP+BEM model, properly describes the vertical arrangement of urban fabric, accounting for the distribution of heat, moisture, and momentum sources throughout the urban canopy layer. Additionally, energy consumption within buildings for both cooling and heating is estimated by the BEM, providing a comprehensive perspective on the urban energy balance. Coupled with a 1-D column model of urban canopy flow, the BEP+BEM offline model accurately estimates drag coefficients and turbulent length scales based on urban fabric characteristics. In the proposed version, the model has been extended to consider additional factors such as green areas and street trees, along with existing green roofs, photovoltaic panels and the permeability of urban materials. This expansion enhances the model's capability to assess the effectiveness of sustainable infrastructure in mitigating climate change effects on urban areas. In this study, the BEP+BEM scheme is forced by data from climate projections, allowing for the dynamic representation of various Local Climate Zones (LCZs) under distinct climatic conditions. Simulations in different LCZs and under different climatic conditions are compared to evaluate the impact of climate change on urban environment, enabling the exploration of how different urban areas respond to changing meteorological forcings. The sensitivity analysis includes a range of standard urban typologies (i.e. LCZs), capturing the complexity of interactions between the built environment and the atmosphere. This approach offers an assessment of the impacts of climate change on key urban phenomena, such as urban heat islands (UHI), thermal discomfort, and heightened energy consumption by buildings. The outcomes of this study provide valuable insights for the urban climate community, policymakers, and researchers with the aim of enhancing the resilience of cities in the face of a changing climate. By bridging the gap between climate projections and urban climate simulations, a consistent framework is presented in this work for evaluating and adapting various urban environments to future climatic conditions.