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Impact of urban geometry on outdoor thermal comfort and air quality from field measurements in Curitiba, Brazil

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ABSTRACT

Urban climate can have severe impacts on people who use outdoor spaces within a city. In its essence, urban climate is directly linked to the configuration of street axes, building heights and their attributes. Thus, the role of urban planners can be crucial for guaranteeing outdoor thermal comfort and air quality in open spaces. This paper presents observed and estimated relations between urban morphology and changes in microclimate and air quality within a city center. Two approaches are presented, showing results of field measurements and urban climate simulations using the ENVI-met software suite. From measured microclimatic data and comfort surveys, carried out in downtown Curitiba, Brazil, the impact of street geometry on ambient temperatures and on daytime pedestrian comfort levels was evaluated, using the sky-view factor (SVF) as indicator of the complexity of the urban geometry. The impact of street orientation relative to prevailing winds and the resulting effects of ventilation (air speed and spatial distribution) on the dispersion of traffic-generated air pollutants were additionally analyzed by means of computer simulations. Results show the impact of urban geometry on human thermal comfort in pedestrian streets and on the outcomes of pollutant dispersion scenarios.

1. Introduction

From the thermal comfort point of view, impacts of urban configuration can be linked to the increased need of air conditioning systems in buildings located in hot regions (or in regions with hot summer season) in order to ensure comfort conditions for their occupants. Consequences of an increased usage of air conditioning can be associated to higher electric energy demand. The creation of urban heat islands interferes with the microclimatic conditions one is exposed to, when working or staying outdoors. Thus, a climate-responsive urban planning can provide optimal, comfortable, thermal conditions for persons using outdoor spaces while alleviating air conditioning demand in buildings.

Curitiba, a city of 2 million inhabitants in southern Brazil, has a long history of urban planning, which started in the 1930s. Later, with an ever-increasing urban growth, the city plan underwent a series of revisions of the Master Plan which led to an innovative mass transportation system capable of supplying current and future demands, as well as measures for preserving the city's heritage and green areas. This planning process, which has attracted worldwide attention as a model of sustainable urban development [1], is based on the principle that land use in the city can be induced, restricted, and organized. Considering the long history of local urban planning and the importance of sustainability considerations in this process, it is considered essential to develop innovative tools for urban climate analysis which could have an application in Curitiba's future growth.

Notwithstanding the longtime tradition of the municipalities in developing innovative urban planning concepts, there is a meager amount of studies concerning outdoor comfort and climate-oriented urban planning in Curitiba. Recent studies regarding the outdoor context refer to: air pollution [2,3], urban noise [4–8], heat islands and air temperature distribution in diverse parts of the city [9–14] and, more recently, to the relationship between urban geometry and comfort levels [15]. Thus, it was considered relevant to launch a research project dealing with the impacts of urbanization on outdoor thermal comfort.

In urban areas, wind conditions have an impact on the potential use of natural ventilation in buildings, on human thermal comfort outdoors and on the dispersion of airborne pollutants. In this paper, we focus on the impact of urban geometry on outdoor thermal comfort, including air quality and airflow in urban canyons, by means of on-site monitoring and microclimate simulation. It is the purpose of the analysis to infer about the relative importance of the comfort variables mean radiant temperature (MRT) and wind speed, which results from urban geometry, on pedestrian thermal comfort and on pollutant dispersal. An additional analysis is presented, concerning the role of wind patterns in both areas.

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