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Multiscale numerical simulations of climate change impact on urban microclimate and human health

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As a result of climate change, projections show that the increasing urban population will be exposed to higher air temperatures (Hayes et al., 2014; Sheffield and Wood, 2008). In addition, due to climatic changes, the frequency and duration of heatwaves are expected to increase while the Urban Heat Island effect (UHI) is expected to become more severe (Emmanuel and Krüger, 2012; Kovats and Hajat, 2008; Mirzaei and Haghighat, 2010), causing increasing heat-related mortality and morbidity (Garssen et al., 2005; Xu et al., 2012). Meditteranean-type climate regions have been characterized as particularly vulnerable to climate change due to their high exposure to extreme weather phenomena (Diffenbaugh and Giorgi, 2012; Paz et al., 2016). The intensity of heat waves in these regions is expected to increase further, leading to other life-threatening consequences for urban populations in the Mediterranean region (Legasa et al., 2020; Zittis et al., 2021). Under this context, the detailed investigation of the impact of climate change on the urban microclimate and human health is considered highly important. This study investigates the impact of climate change on urban microclimate and pedestrian thermal comfort through a series of numerical simulations. For this purpose, 3D Computational Fluid Dynamics (CFD) simulations are performed based on the Unsteady Raynolds-Average Navier-Stokes (URANS) equations for urban microclimate in a real compact heterogeneous urban area. The CFD validation is based on high-resolution field and laboratory measurements of the case study area in Nicosia, Cyprus (Antoniou et al., 2019, 2017). Simulations are performed for meteorological conditions based on field measurements performed in 2010, and for predicted meteorological conditions for 2050 derived from downscaled Regional Climate Models (RCMs). The RCM data are derived from the European Coordinate Regional Downscaling Experiment (EURO-CORDEX) database. CFD results are combined with radiation modeling results of the same urban area to calculate pedestrian thermal comfort using the Universal Thermal Comfort Index (UTCI). The results show that by 2050, a 2.3 °C increase in the maximum air temperature is expected to occur, which can lead to a more than 240% increase in heat-related mortality. In addition, an increase of UTCI levels is also expected, which is more pronounced in the late afternoon hours, reaching up to 4.3 °C increase at 20:00. A significant change in the thermal stress categories is also identified between the 2010 and 2050 scenarios, where “very strong heat stress” conditions (UTCI: 38-46 °C) are expected to prevail for twice as long, increasing from 3.3 to 6.6 hours, and “extreme heat stress” conditions (UTCI > 46 °C)

appear at some locations of the area in 2050.