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Implementation of a newly developed Photonic Meta-Concrete into the COSMO-CLM model to estimate the impact on the urban heat island: a case study of Flanders, Belgium

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Radiative cooling (RC) materials gained interest over the past decades, as these can help mitigating the urban heat island effect, fighting climate change and reducing the cooling demand for buildings. Their altered photonic properties, albedo and emissivity, enable these materials to cool down below ambient temperature and radiate heat in the atmospheric spectral window (8-13 µm), effectively releasing heat into space. Current RC materials typically consist of thin layers of metal and polymer, manufactured through energy-intensive and costly manufacturing processes. The Horizon 2020 project 'MIRACLE' is developing a new innovative radiative cooling material, that for the first time, is based on conventional concrete.

This study quantifies the effect of the Photonic Meta Concrete (PMC) on the climate of the highly urbanized region of Flanders, Belgium (13600 km²). Modelling such a large area allows to explore the impact on the urban heat island across multiple cities with diverse geometrical and geographical properties. More specifically, this study assesses the urban heat island effect of selected cities during a heatwave in August of 2019, comparing scenarios with and without the implementation of PMC in the built environment. The COSMO-CLM regional climate model, utilizing the TERRA-URB urban-canopy land-surface scheme, is employed for this assessment. Integration of the PMC's photonic properties, i.e. the specific emissivity and albedo, into the urban canopy scheme is achieved by adapting the land surface parameters using the Semi-empirical Urban CanopY parametrization (SURY). Comparisons are made between scenarios incorporating specific albedo of the PMC, specific emissivity of the PMC or both against a baseline scenario without the PMC implementation. These comparisons aim to estimate the mitigation potential offered by this innovative material.

Initial findings suggest that the PMC shows promising potential for lowering city temperatures, with the albedo being identified as the primary factor in combating the urban heat island effect. In Brussels, surface temperatures drop by as much as eight degrees, while temperatures at a height of two meters decrease by up to two degrees