EMS Annual Meeting Abstracts
Vol. 14, EMS2017-742-2, 2017
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The impact of façade orientation and vegetation on summer heat stress – measurements and simulations from a rectangular Central-European square

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Around three quarter of the European population already lives in urban areas and by 2050 this proportion is expected to rise over 80%. Since climate change is expected to bring rising temperatures and more frequent heat waves, mitigating the impact of extreme heat events is one of the most important issues in urban planning. Nature-Based Solutions (NBS) is a recently introduced concept in environmental research and management that promotes nature as a means to address the challenges brought about climate change. Researches of human-biometeorology demonstrated that radiation heat load, quantified as mean radiant temperature (Tmrt), is the main source of daytime heat stress in summer. In European cities–especially in those with dense historic urban cores–carefully planned and properly maintained shade trees constitute the most effective NBS for mitigating extreme thermal conditions, while also offering several co-benefits.

This study was conducted with the following two aims: (a) to assess the impact of woody vegetation and different façade orientation on the radiation heat load in a complex urban setting; and (b) to evaluate the performance of SOLWEIG, a radiation model, in reproducing the measured short- and long-wave radiation flux densities. The observation was conducted over a 26-hour long period at the rectangular Bartók Square in Szeged (Hungary) on a clear and warm late-summer day. The investigation utilized two tailor-made human-biometeorological stations equipped with rotatable net radiometers. The model–measurement comparison is based on data collected from five locations within the square: from the center and from four sites next to the bordering façades.

The measurements confirmed that on clear summer days Tmrt can reach extreme level at exposed locations (65–75°C). However, shade trees are able to reduce daytime Tmrt to 30–35°C. Shading SE-, S- and SW-facing façades and adjacent sidewalks is extremely important for the reduction of pedestrian heat stress and thus, the risk of heat stroke. When a measurement point adjacent to a facade became exposed to direct solar radiation, the radiation load increased significantly due to the additional lateral components–the reflected short-wave and the emitted long-wave fluxes–emanating from the wall. In this respect, SOLWEIG was unable to reproduce the prolonged heat emitting effect of walls following solar exposure. Additionally, the measurement–model comparison revealed minor inconsistencies that originated from the model's treatment of tree crowns: representing them as perfectly shaped and homogeneous bodies. Due to this simplification, the observed brief penetrations of direct sunbeams through the canopy at most locations were not reproduced.