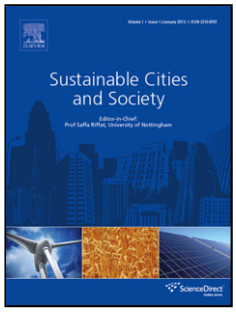

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PII: S2210-6707(18)30461-X
DOI: https://doi.org/10.1016/j.scs.2018.07.016
Reference: SCS 1186

To appear in:

Received date: 12-3-2018
Revised date: 22-6-2018
Accepted date: 21-7-2018

Please cite this article as: Tsoka S, Theodosiou T, Tsikaloudaki K, Flourentzou F, Modeling the performance of cool pavements and the effect of their aging on outdoor surface and air temperatures, *Sustainable Cities and Society* (2018), https://doi.org/10.1016/j.scs.2018.07.016

Modeling the performance of cool pavements and the effect of their aging on outdoor surface and air temperatures

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Highlights

- The high albedo materials' effect is evaluated for the design and aged albedo values.
- Increasing ground surfaces' albedo by 0.28-0.40 led to major Tsurf drop of 9.0□C.
- Peak Tair drop up to 0.85oC was achieved for the 'design' high albedo values.
- The materials' cooling potential was highly reduced for the aged albedo values.
- The achieved Tair drop due to cool materials decreases by 8% for every 3m height.

Abstract

Aiming at the improvement of a dense urban area's microclimatic conditions, this study examines by simulation means, the application of highly reflective materials as a mitigation strategy. Yet, as significant albedo changes may occur due to weathering and aging, the study investigates the surface (Tsurf) and air (Tair) temperature cooling potential of cool paving materials, both for design and aged values of solar reflectance; the aged albedo values are issued from previously reported experimental campaigns. Since the majority of the existing studies evaluate the cool materials impact at the pedestrian's height, the current work aims to provide insight on the vertical profile of the achieved Tair reduction due to cool pavements, at different heights of the study area canyons. The analysis revealed that the Tsurf and Tair decrease due to cool pavements is reduced by 50%, when the aged albedo values are considered while the obtained Tair reduction is negatively related to the distance from the ground. The accurate assessment of the high albedo materials' effect on the urban microclimate imposes thus the consideration of the albedo degradation due to weathering and aging while extra effort should be given on the development of cold materials standing the test of time.

Keywords: microclimate; Envi-met; cool materials; albedo; aging

1. Introduction

The term 'urban microclimate' is generally used to express the divergence of atmospheric conditions occurring in an urban area, compared to those of the surrounding rural areas. This differentiation, well-known as the 'Urban Heat Island' effect, is characterized by higher ambient air temperatures (Tair) a reported in the urban districts when compared to the rural ones ([1], [2], [3]) and it is attributed to various uncontrollable and controllable parameters [4]. The uncontrollable factors refer to environmental and nature related parameters whereas the controllable ones involve urban planning and design parameters. Based on the existing literature, the main humanly controlled factors, identified as a source of higher ambient Tair in urban areas involve:

- The decrease of latent heat flux through evapotranspiration as a consequence of vegetation loss ([5], [1]),
- The large quantities of solar radiation stored and then re-emitted as long-wave radiation inside the urban districts, as a result of the urban materials' thermophysical properties [6],
- The high surface temperatures (Tsurf), and the severe intensity of long wave radiation emission due to the low albedo value of the construction materials [7],
- The high urban densities, contributing to the entrapment of shortwave and long wave radiation inside the canyons inhibiting thus, the urban cooling ([8], [9]).

The occurrence of high ambient Tair in the urban areas along with its negative environmental, social and energy impact consists a very well documented phenomenon worldwide ([10], [11], [12], [13], [14], [15], [16], [17], [18], [19]); in the