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# Aerial survey and in-situ measurements of materials and vegetation in the urban fabric

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**Abstract**

The integration of microclimatic information and energy balance of the materials into urban design is essential for adequately addressing the challenges related to climate change and to adaptation of urban environment to new climatic loads. Several studies model the urban climate from multispectral satellite measurements. However, the remotely sensed measurements usually have a spatial resolution of several meters and are not suitable for determining microclimate effects in urban areas and on individual buildings. Moreover, they require consideration of the intervening atmosphere and the surface radiative properties that influence the emission and reflection of radiation within. The present research approach includes in-situ measurements and aerial surveys with VIS/NIR multispectral camera and IR camera mounted on a UAV. Analysis presented here, aims (1) to identify physical characterization of reflectance properties in a variety of urban settings in Athens, (2) to explore the response of vegetation, cool and conventional materials in the NIR region (3) to study climate parameters essential to the bio-climatic design in this urban cover (4) to elaborate observational studies for obtaining better validation of the surface effective parameters derived. The sensors on UAVs provide a unique perspective of urban features for revealing the complex mechanisms that lead to micro-climatic modifications and to quantify their relative contribution. The application of NIR images in building and urban scale analysis is innovative and reveals different properties of the surface of the objects.



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*Keywords:* Urban microclimate;UAV; IR; NIR; aerial survey;vegetation; materials;surface temperature

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## 1. Introduction

Globally, more than half of the population lives in urban areas [1]. Consistent knowledge about cities, their structure, materials and vegetation is of high relevance for urban based adaptation and mitigation strategies in response to climate change [2]. IPCC [3] notes the dearth of information on urban areas at detailed spatial and temporal resolution and the importance to derive comprehensive databases on cities and develop urban climate models. To understand the urban climate a thorough consideration of many parameters, such as urban morphology, land cover, moisture availability, anthropogenic heat and material properties, is required.

The properties of the materials used in the urban fabric play an essential role in the energy balance which modifies the microclimate [4]. Their thermal performance is mainly determined by the physical characteristics, optical and thermal [5]. The most significant factors related to radiation exchange are the albedo to solar radiation and the emissivity to long wave radiation [6]. The application of materials that present high reflectivity during summer period has gained a lot of interest during the last years as a mitigation strategy of the heat island effect [7]. These materials namely cool are characterized by high solar reflectance and infrared emittance values resulting in lower surface temperatures. Cool pavements refer to a range of established and emerging materials that tend to store less heat and have lower surface temperatures compared to conventional ones [8,9].The vegetation influences the urban climate by moderating the solar and terrestrial radiation wind and rain, mitigates the greenhouse effect, filters pollutants, masks noise and prevents erosion [10]. Sufficient surface water permeability is vital for urban hydrology as intense rainfall can trigger local flooding in densely urbanized areas [11].

The surface temperature is of prime importance as it modulates the temperature of the lowest atmospheric layers and is central to the surface energy balance. A great deal of information on surface temperatures can be obtained through thermal remote sensing imagery, e.g. Voogt and Oke [12] give a scientific overview of thermal remote sensing capabilities in urban climate. When remotely-sensed imagery is available, valuable information can be extracted on the properties of the materials.

However, as the remotely sensed measurements usually have a spatial resolution of several meters, they are not suitable for modeling microclimate effects in urban areas and on individual buildings. Moreover, they require consideration of the intervening atmosphere and the surface radiative properties that influence the emission and reflection of radiation within. The development of Unmanned Aerial Vehicles (UAVs) and of small spectral imaging sensors makes it possible to obtain spectrally resolved images at very high spatial resolution in an easy and flexible way. The UAVs as a sensor platform to support microscale measurements provide flexibility in the timing of data captured and the scale of the images obtained [13].

The use of Infrared sensors is an important tool in many close range applications. Thermal infrared cameras (in the bandwidth $3.5\mu m < \lambda < 14\mu m$) provide the visualization of thermal differences on the surface of an object [14]. Moreover, the integration of near infrared (NIR) camera ($0.75\mu m < \lambda < 3\mu m$), accumulates further radiometric info on the thermal properties of the materials and is a well-established tool for the analysis of vegetation [15]. In addition, the Normal Difference Vegetation Index (NDVI) is widely adopted in vegetative studies [16] and ground parameters such as ground cover and surface water.

The aim of this study is to address all these issues with a high definition surveying. This paper presents a classification-based methodology for surface emissivity mapping and surface temperature distribution over the examined area by combing airborne data, in-situ measurements and emissivity values.

## 2. Description of the site

The study area was in Ymittos Municipality, which is a suburb, situated 2.5 km southeast from the center of Athens, Greece. Subsequent to the administrative reform of Kallikratis Plan in 2011, it is part of the municipality Dafni-Ymittos. The Municipality has according to the official census of 2011, 33628 inhabitants and occupies an area of 2.35 square kilometers. The typical Mediterranean climate in this area is characterized by hot, dry summers and cool, wet winters.