ARTICLE IN PRESS

Urban Climate xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

A satellite-based system for continuous monitoring of Surface Urban Heat Islands

Panagiotis Sismanidis [a,b,*], Iphigenia Keramitsoglou [a], Chris T. Kiranoudis [a,b]

[a] Institute for Astronomy, Astrophysics, Space Applications, and Remote Sensing, National Observatory of Athens, Athens, Greece
[b] School of Chemical Engineering, National Technical University of Athens, Athens, Greece

ARTICLE INFO

Article history:
Received 2 March 2015
Revised 9 May 2015
Accepted 5 June 2015
Available online xxxx

Keywords:
Urban Heat Island
Remote sensing
Land surface temperature
Real time service
LST downscaling
Earth Observation

ABSTRACT

The increased temperatures of urban areas raise significant economic and health-related issues that affect more than half of the world population. This fact raised the need to assess and monitor the urban thermal environment and spurred the development of supportive information for decision-making, such as heat wave risk maps. Most of these require access to high spatiotemporal temperature measurements so as to be fully effective. However, even to this day, such datasets are difficult to obtain. Many remote sensing scientists support the view that the spatial enhancement of geostationary satellite land surface temperature data (LST) can provide the needed datasets. This approach has received significant attention in recent years and considerable progress was made in the development of relevant algorithms. The objective of this article is twofold. Firstly, to introduce the reader to the processing chain that leads to the production of spatially enhanced LST data, and secondly to highlight the exploitability of such datasets. This article presents these in the context of a service that the Institute for Astronomy, Astrophysics, Space Applications, and Remote Sensing of the National Observatory of Athens (IAASARS/NOA) is implementing, which aim is to operationally provide high spatiotemporal urban temperature data to several different end-users.

* Corresponding author at: Institute for Astronomy, Astrophysics, Space Applications, and Remote Sensing, National Observatory of Athens, Vas. Pavlou & I. Metaxa Str., GR-15236, Penteli, Greece. Tel.: +30 210 810 9167.

E-mail address: panosis@noa.gr (P. Sismanidis).

http://dx.doi.org/10.1016/j.uclim.2015.06.001

Please cite this article in press as: Sismanidis, P., et al. A satellite-based system for continuous monitoring of Surface Urban Heat Islands. Urban Climate (2015), http://dx.doi.org/10.1016/j.uclim.2015.06.001

1. Introduction

The last decades have been marked by a global change in the distribution of the world population. This was due to urbanization and industrialization that caused the rapid relocation of rural dwellers to urban centers (Schneider et al., 2010). A direct result of this trend was the rapid expansion of the urban areas and the subsequent conversion of pervious surfaces (e.g. rural and vegetated lands) to impervious (e.g. rooftops, roads, sidewalks). The latter have higher thermal conductivity and heat storage capacity in comparison with pervious surfaces, and also lower overall albedo (Barnes et al., 2012). Thus, they alter the local energy balance and affect the local climate. This change, alongside (1) the decrease in evapotranspiration; (2) the reduction in turbulent heat transport due to the geometry of the street canyons; (3) the anthropogenic heat fluxes; and (4) the air pollution, causes the urban heat island (UHI) effect (Oke, 1982; Stathopoulou et al., 2004; Xiao et al. 2007).

The UHI effect refers to the relative warmth of the dense urban areas with respect to their suburban/rural surroundings. This thermal anomaly may occur during daytime or nighttime and exhibits strong spatial, vertical, and temporal variations. These variations depend on the different rates of warming and cooling that characterize each land cover type and material (Oke, 1982; Stathopoulou et al. 2004; Voogt and Oke, 2003). Moreover, the UHI phenomenon has been related to a range of issues, such as energy demand, and human health (Deng and Wu, 2013; Lo et al., 2010; Tan et al., 2010; Weng, 2014). To appreciate its importance, UHI can increase the magnitude and duration of heat waves in dense urban environments where the majority of the population reside and thus lead to higher mortality rates (Lo et al., 2010; Tan et al., 2010). In addition, an increase in the ambient urban temperature above a certain threshold will lead to a higher energy demand for air-conditioning (Kolokotroni et al., 2012; Stathopoulou et al., 2006). It is important to emphasize again that these effects primarily impact the urban areas, i.e. the areas with the greatest concentration of people, and thus their impact on human welfare and health is exacerbated. The importance of assessing, monitoring, and mitigating (cooling) UHIs has been realized by the scientific community and has received significant attention in recent years.

In particular, added-value parameters have been proposed that exploit *in-situ* air temperature (AT) data and/or remotely sensed land surface temperature (LST) data so as to facilitate the study of UHIs (both atmospheric and surface) and their effects (the surface UHI will be abbreviated in text as SUHI). These added-value parameters can also support decision-making. Some examples are: (1) heat indices that attempt to define heat stress and the zones of discomfort (Epstein and Moran, 2006; Mayer and Höppe, 1987; Nikolopoulou and Lykoudis, 2006); (2) the study of the spatial patterns of the surface temperature that enables the analyses of the intensity, position, and spatial extent of UHIs (Cao et al., 2010; Keramitsoglou et al., 2011; Stathopoulou and Cartalis, 2007); (3) the cooling-degree-days (CDD) and cooling-degree-hours (CDH) which are means for assessing the energy demand (Kolokotroni et al., 2012; Stathopoulou et al., 2006); (4) heat wave (HW) risk and hazard maps (Keramitsoglou et al., 2013b); and (5) the diurnal analysis of the UHI phenomenon that depicts its highly dynamic behavior (Kim and Baik, 2005; Liu et al., 2006; Weng, 2014 p. 256).

However, most of these added-value parameters are limited by the spatial and temporal resolution of the urban temperature datasets (i.e. AT or LST) that they exploit. In particular, AT data acquired by *in-situ* meteorological stations offer long time series of excellent temporal resolution but poor spatial coverage, while the acquisition of LST is limited by the trade-off between the spatial and temporal resolution that characterizes all remote sensing systems. Specifically, three main categories of remote sensing sensors can be defined: the first one refers to the sensors that offer LST data with high spatial and low temporal resolution (e.g. semimonthly acquisitions with a pixel size smaller than 200 m); the second to those that offer LST data with medium spatial and temporal resolution (e.g. two images per day with a pixel size of 1 km); and the third one to the sensors that acquire LST data with low spatial but high temporal resolution (e.g. quarter-hourly acquisitions with a pixel size larger than 3 km). It is clear from the above that none of these data sources can provide the urban temperature datasets that combine the appropriate spatiotemporal characteristics to monitor such a temporally and spatially dynamic phenomenon as the UHI. Ideally, high spatiotemporal urban temperature datasets with spatial resolution, comparable to the size of a building block (∼100 m, it has to be noted that even this