MODIS-BASED INVESTIGATIONS ON THE URBAN HEAT ISLANDS OF BUCHAREST (ROMANIA) AND PRAGUE (CZECH REPUBLIC)

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Abstract

The scientific purpose of this study is to investigate the spatial extension and the magnitude of the heat islands of two significant urban agglomeration, the cities of Bucharest (Romania) and Prague (Czech Republic). In order to emphasize the urban heat island (UHI) of the two cities, rectangular areas of about 100 x 100 km were delimited around them, with the cities in the centre of the squares. These periurban areas include towns and villages, significant woodlands and aquatic surfaces, as well as extended agricultural land. The surface temperatures have been derived from Moderate Resolution Imaging Spectroradiometer (MODIS) images, MOD11_L2 product, both from Terra and Aqua satellites, ranging from 2000 to 2006. The satellite-derived temperatures have been compared with the ground-based temperatures in order to identify possible errors. We have calculated the magnitude of the UHIs of Bucharest and Prague as the difference between the highest temperature inside each city and the lowest temperature in the periurban areas surrounding them. Cross-profiles through the cities have documented the assessment of the spatial extension of the UHIs. We have approached two temporal patterns, striving to evaluate the seasonal and the diurnal variability of the UHIs in the two cities. The study retrieves that the local topography plays an important role in the characteristics of the urban heat island (i.e. Bucharest is situated in a much more flat area than Prague, with no influent watercourse passing through and therefore the UHI of Bucharest is more extended and more intense than the one of Prague).

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INTRODUCTION

Regardless of its size, every settlement influences the meteorological elements, and the urban climate is a theme extensively approached over the decades (a few remarkable overviews: Landsberg, 1981; Oke, 1984; Arnfield, 2003). The remote sensing investigations of the urban heat island (UHI) are rapidly developing in the recent years, taking advantage of the significant improvements in the accuracy and the cost of the images (Streutker, 2002; Jin and Shepherd, 2005; Pongracz et al., 2005).

METHODOLOGY AND OBJECTIVES

This research is conducted on the basis of thermal data provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors aboard the Terra (EOS AM) and Aqua (EOS PM) Satellites. Two MODIS products, MOD11_L2 and MYD11_L2, supply instantaneous views of the Land Surface Temperature (LST), at a 1-km resolution, two times a day each two night-time and two day-time images, and they were used consequently for deriving the UHI of Bucharest (Romania) and Prague (Czech Republic) (Fig. 1a and 1b). The images cover the interval 2000-2006, the months of July. For each selected city, the mean LST was calculated, for day-time and for night-time separately. For each pixel, the LSTs were filtered using the ‘average +/- 2 standard deviations’ filter. The filtered averaged data for each pixel were interpolated using GIS techniques; the Urban Heat Islands were thus
revealed. The extensions of the UHIs were evaluated based on cross-profiles: the changing points along each profile were identified based on the Rodionov test (Rodionov 2004), and they were considered indicators for UHI extension. Differences between the temperature inside the urban area and the one in the surrounding area were retrieved, as a measure for the magnitude of the UHI. Land use investigations were performed based on CORINE data (CLC 2000).

The main objective of this study is to comparatively investigate the Surface Urban Heat Island (SUHI) of the cities of Bucharest (Romania) and Prague (Czech Republic), in terms of magnitude, geometry, and extension, using satellite images (MODIS products).

The city of Prague has 1 200 000 inhabitants, (11.5 % of the population of Czechia), approx. surface 496 sq. km. The city of Bucharest has 2 000 000 inhabitants (10% of the population of Romania), 240 sq. km.

Figure 1a: Digital elevation model for the area of Bucharest
RESULTS

Shapes, magnitudes and extensions of the UHIs of Bucharest and Prague can be seen on Figs. 2 and 3, always for night and day respectively. Land cover data with the borders of July UHIs in Bucharest and Prague are given on Figs. 4 and 5, here we can compare the size and shape of UHIs with the land cover data and we see quite good correlation with urban fabric areas and industrial and traffic units and sites. Finally, we have also computed differences between the average temperature in the UHI and the average temperature in its proximal 5 km (UHI+5) and 10 km (UHI+10) during the Day (A) and night (B) for Bucharest. They can be seen on Figs. 6 and 7, again for night and daytime separately.
Figure 2: Day (A) and night (B) LST in Bucharest derived from July MODIS images (2000-2006)

Figure 3: Day (A) and night (B) LST in Bucharest derived from July MODIS images (2000-2006)
Figure 4: Land cover and July UHIs in Bucharest
Figure 5: Land cover and July UHIs in Bucharest
DISCUSSION

This first attempt of using satellite data in quantification the effect that the cities of Bucharest and Prague have on the land surface temperatures have provided encouraging results, despite the difficulties induced by the relatively short range of datasets. The remote sensing techniques prove to be extremely helpful in assessing the characteristics of the Urban Heat Islands. In some cases of cities, where the ground-based weather stations are not capable to record most of the urban climate characteristics, the satellite images give valuable information. The extension, the geometry and the magnitude of the Bucharest and Prague UHIs are notably influenced by the land cover. They vary from day- to night-time due to the differences in the radiative behavior of the land cover. One can assume that other factors like air mass circulation or cloudiness trigger some features of the UHI. Studies for further time periods as well as for other cities in Romania and Czech Republic are planned.

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REFERENCES


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