5.5 THE ROLE OF LAND-USE PARAMETERS IN THE SPATIAL DEVELOPMENT OF URBAN HEAT ISLAND IN SZEGED, HUNGARY

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1. INTRODUCTION

The modification effect of urbanization on local climate is most obvious in case of temperature, which phenomenon is the so-called urban heat island (UHI) or urban heat archipelago if the structure is multi-cellar. Statistical modeling may provide useful quantitative information about the structure as well as spatial and temporal features of the maximum UHI intensity by employing different urban surface factors (Oke, 1981, 1988; Kuttler et al., 1996). In our case these factors are the built-up ratio, the sky view factor and the building height. The selection of the parameters is based on their role in small-scale climate variations (Golany, 1996). The purpose of this study is to determine influences of the urban surface factors on the patterns of urban-rural temperature differences quantitatively in the non-heating half years.

2. STUDY AREA

The investigated area, Szeged, is in the south-eastern part of Hungary on a wide flat flood plain. Within an administration district of 281 km^2 live 160,000 inhabitants. The city has several land-use types. Urban and suburban areas occupy only about 25–30 km^2, therefore our examination concentrated on the central parts of the large administration district. This area was divided into two sectors and subdivided further into 500 m $\times$ 500 m squares, so it contains altogether 107 grid cells (26.75 km^2). Because of a lack in the data of one parameter used in our investigation, present study employs a bit less, altogether 97 cells (24.25 km^2).

3. PARAMETERS AND METHODS

Spatial and temporal distribution of surface air temperature was based on mobile observations during the period of March 1999 – February 2000. The determination of urban-rural air temperature differences (UHI intensity) of cells was based by reference to the temperature of the most western cell, which was regarded as rural because of its location outside of the city.

3.1 Built-up ratio and distance from the centre

The ratio of the built-up surface by cells was determined by vector and raster-based GIS database combined with remote sensing analysis of SPOT XS images (Unger et. al., 2001). The distance from the centre describes the relative location of a cell inside of the city which means the distance between the central cell and the given one.

3.2 Sky view factor

It was also necessary to determine quantitatively the representative openness of surfaces by cells. In our work we used the sky view factor (SVF) which is a dimensionless measure and its value is between 0 and 1 (Oke, 1981, 1988). In order to determine SVF values the same canyons (measuring route) was used as for temperature sampling. The obtained data set is important because we have SVF values almost from the total urban area while the earlier investigation connection with SVF were limited to the central or only one part of the cities (Oke, 1981, 1988; Park, 1987; Eliasson, 1996; Grimmond et al., 1999). Since the areas with different land-use features can produce almost equal SVF data this values alone do not describe sufficiently the vertical geometry of cities.

3.3 Building height

Both the highest point of both sides of the canyon and the angles between horizontal plane and the highest points seen from the measuring points are available in each measuring point. If we know the distances of the walls from the measuring point exactly we can calculate the height of walls. After digitizing these images, we made an orthophoto of Szeged by means of Ortho Base tool of ERDAS IMAGINE GIS software. The measurement points were also precisely marked on it. This orthophoto already suitable to determine distances of the walls from the measuring point for every point in each cell.

4. RESULTS AND DISCUSSION

4.1 Spatial characteristics of urban parameters

In the non-heating season the shape of the UHI patterns are almost concentric and the temperature values are increasing from the outskirts towards the inner urban areas (Fig. 1). In the non-heating season, the greatest intensity (3.18 ºC) is found in the central grid cell and the mean maximum UHI value of higher than 2 ºC covers about 37% of the investigated area (Unger et al., 2000).

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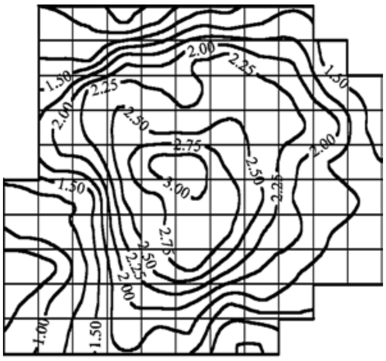

Fig. 1. Spatial distribution of the measured mean max. UHI intensity (ºC) during the non-heating season (April 16 – October 15)

There are some essential deviations in the concentric shapes of the UHI intensity field but the most important one extends from north-eastern to south-western part of the city.

The spatial distribution of the built-up ratio over the city has also concentric shape basically decreasing from the central urban areas to the outwards (Unger et. al., 2001). There are three parts of the city where the SVF values are very low so this parameter considerably influences the outgoing longwave radiation there. At these areas the values are lower than 0.8 and in the middle of the city are lower than 0.7. The highest buildings are located in the north-eastern part of the city with maximum values of about 20 m. The average building height is higher than 10 m in the study area.

4.2 Statistical model

In the course of determination of the model equations we used mean maximum value of UHI intensity (ΔT) and the earlier mentioned parameters, such as: distance from the central grid cell (D) in km, sky view factor (SVF), building height (H) in m and ratio of built-up surface (B) in percentage. The sequence of the parameters entered in the multiple linear stepwise regression was determined with the help of the magnitude of the bivariate correlations coefficients. The 4-variable equation (1) show very strong linear connection (F-test significance level < 0.1%) between the mean max. UHI intensity and the applied land-use parameters in the non-heating period.

$$\Delta T = -0.541D - 0.389SVF + 0.029H + 0.004B + 4.917 \quad (1)$$

It is well observed, that there is a fundamental similarity between the measured and predicted UHI intensity field in both season but one can detect some differences too. As it can be seen in Fig. 2, the calculated ΔT fields have also three significant irregularities over Szeged therefore the generally concentric shape of these UHI fields is changed. Towards the north-eastern part of the city the isotherms are considerably streched. This can be explained by the influence of the large housing estates with tall concrete buildings located mainly in this part of the city so this area has higher than 75% built-up ratio, buildings higher than 15 m, but less than 0.85 SVF as well. The other irregularity is caused by cooling influence of Tisza River flows across the city from east to south-west.

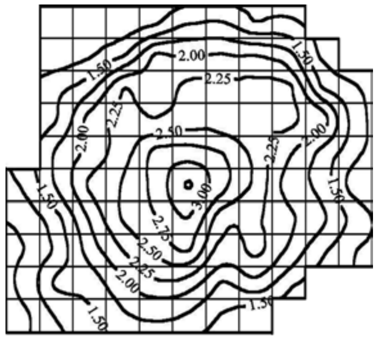

Fig. 2. Spatial distribution of the predicted mean max. UHI intensity (ºC) during the non-heating season (April 16 – October 15)

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