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URBAN HEAT ISLAND ATLAS: A WEB TOOL FOR THE DETERMINATION AND MITIGATION OF URBAN HEAT ISLAND EFFECTS

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Introduction

Within the framework of the EU Central-Europe project: 'Development and application of mitigation and adaptation strategies and measures for counteracting the global Urban Heat Islands phenomenon (UHI)', a data base and web atlas was prepared. The Urban Heat Island Atlas was produced by the Anton Melik Geographical Institute, ZRC SAZU. The database was elaborated in the GIS environment using ArcGIS Desktop and published online using the *Arcgis server* programme at http://giam.zrc-sazu.si/uhi_atlas.

About urban heat islands

In urban areas, average temperatures are higher than in the surroundings. These areas of higher temperatures are called 'urban heat islands' – UHI. Higher temperatures lead to enhanced direct heat stress. Several indirect effects such as worse air quality, limited water resources and energy supply problems may occur. By proper mitigation and adaptation measures it is possible to limit the temperature increase, in order to avoid high risks for the quality of life and health of the inhabitants in urban areas.

Data layers presented in the UHI Atlas

Better understanding is key to appropriate behaviour and building characteristics of urban areas. Therefore, the UHI Atlas is a tool for presentation and exploration of different factors which influence the urban heat island phenomena in the Central European area. Various factors are presented, such as elevation, vegetation status (vegetation index), land use/cover, and settlement

density presented by night scene image. The atlas consists of several layers in GIS environment, namely (Fig. 1):

- elevation,
- normalized difference vegetation index,
- land surface temperature,
- air temperature at 2 m,
- land cover and land use,
- night scene,
- project partner data.

sented by raster satellite data of normalized difference vegetation index – NDVI. Vegetation indices are used for global monitoring of vegetation conditions and may be used for characterizing land surface biophysical properties. The data in 1 km resolution cover all Central Europe. Different examples of NDVI are presented for spring, summer and autumn seasons by calculated 16-day average, based on MODIS (moderate resolution

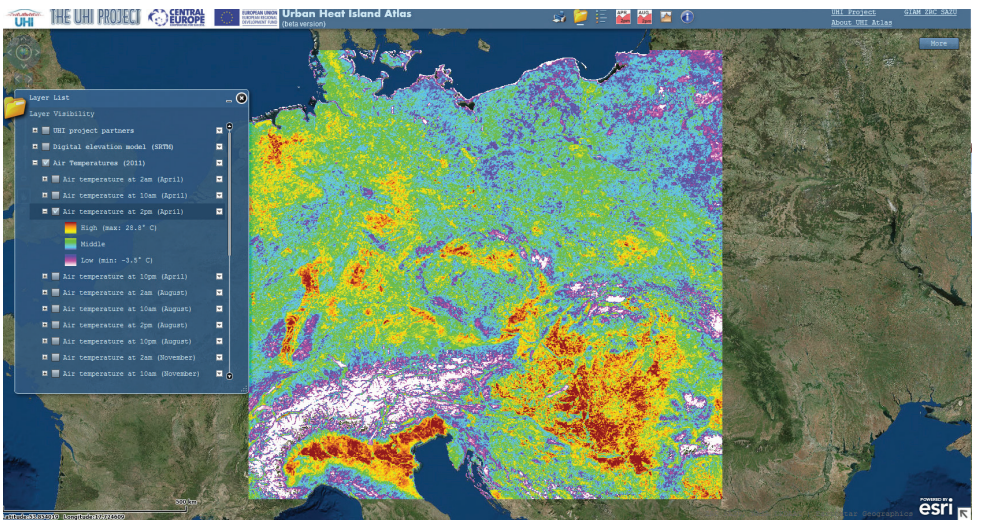

Figure 1. Print screen of Urban Heat Island Atlas for Central Europe – general scale

Source: http://gismo.zrc-sazu.si/flexviewers/UHIAtlas/.

One of the basic factors that influences the climate is elevation. The NASA (National Aeronautics and Space Administration) shuttle radar topographic mission (SRTM) has provided digital elevation data for over 80% of the globe (last update: 2008). The SRTM digital elevation model is a very useful raster data layer. DEM enables us to calculate various relief parameters, such as slope, aspect, and curvature. It has a resolution of 3 arc seconds, which is 90 x 90 m at the equator and approximately 60 x 90 m in Central Europe. Digital elevation models are available for direct download on CGIAR Consortium for Spatial Information website (Jarvis et al. 2008). Vegetation, as an important urban heat island influencing factor, is presented by raster satellite data of normalized difference vegetation index – NDVI. Vegetation indices are used for global monitoring of vegetation conditions and may be used for characterizing land surface biophysical properties. The data in 1 km resolution cover all Central Europe. Different examples of NDVI are presented for spring, summer and autumn seasons by calculated 16-day average, based on MODIS (moderate resolution imaging spectroradiometer) satellite images. The images are taken in different bands and can be downloaded at the US Geological Survey (USGS) website (NASA 2011). Air warms the earth by long-wave radiation and thus land surface temperature (LST) is tightly connected to air temperature. Different examples for spring, summer and autumn (8-day average) are included in the UHI Atlas. They are composed from the daily 1-kilometer LST products that were produced on the basis of images taken by the MODIS sensor. The data layers clearly show differences in land surface temperature, i.e. between forest and urban areas. The images are freely available at the USGS web site or other satellite image browsers (NASA 2011). The atlas also

presents data for air temperature at 2 m above the ground for various seasons in 2011. The data cover all Central Europe area. Air temperature was calculated on the basis of MODIS Land Surface Temperature (LST) by K. Zakšek and K. Oštir from the Research Centre of the Slovenian Academy of Sciences and Arts (ZRC SAZU). The calculation method was presented in the paper: Estimation of daily mean air temperature from MODIS LST in Alpine (Colombi et al. 2007). Land cover and land use are other factors that strongly influence the microclimate. UHI Atlas presents two sources: *Corine land cover* is available for the entire Central European area, while *Urban atlas* data are detailed land use maps covering the area of the project cities. Corine land cover is included as raster data with 100 m resolution. It shows land cover in 2006 and was produced on the basis of satellite images. Two kinds of satellites provided imagery for CLC2006 project: the French SPOT-4&5, and the Indian IRS P6. Corine land cover data are available for download at European environmental agency website (CLC 2012). Vector data of the Urban atlas 2005-2007, in 1:10,000 scale, are also presented for the project cities: Budapest, Ljubljana, Prague, Stuttgart, Venice, Vienna, and Warsaw. The 'European urban atlas' provides high-resolution land use maps for more than 300 urban areas in Europe with their surroundings. The areas were selected according to the population number. Cities with more than 100,000 inhabitants are presented, as defined by the urban audit for the reference year 2006. The Urban atlas was provided by the European environment agency (Urban atlas 2010). Its user friendly interface enables users to select between different layers, make profiles across April (as on Fig. 2) and August temperatures in Central Europe and zoom to UHI partner data.

Night scene satellite images can evidently expose densely populated areas, especially bigger cities, and areas with intense human activity, such as industrial zones, oil rigs and highways etc. Images taken by the VIIRS sensor (Visible Infrared Imaging Radiometer Suite) in 2012 with a 750 m resolution were included in the UHI Atlas to show human presence. VIIRS is a scanning radiometer that collects visible and infrared imagery and radiometric measurements of the land, atmosphere, cryosphere, and oceans. Images

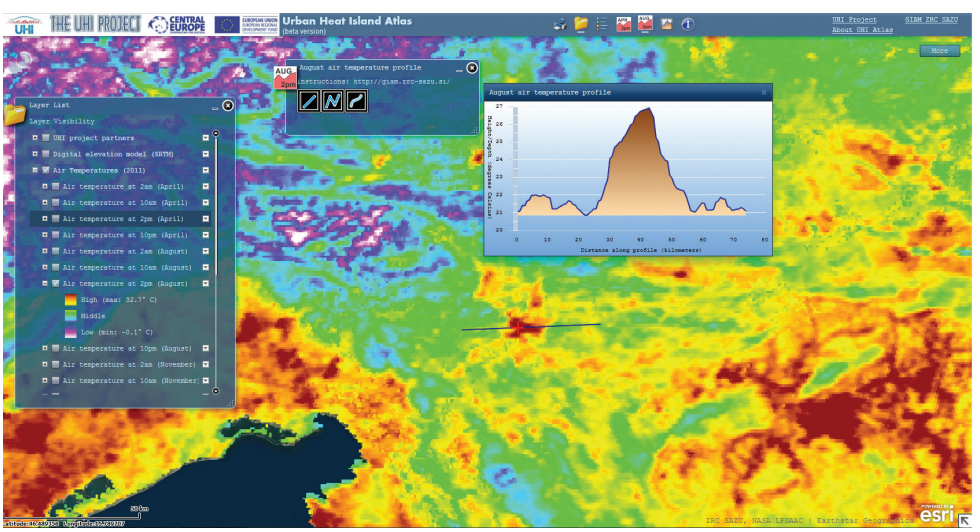

Figure 2. Print screen of Urban Heat Island Atlas – profiles

Source: http://gismo.zrc-sazu.si/flexviewers/UHIAtlas/.

are produced by the NASA Earth Observatory (NASA 2012).

One of the main chapters of the UHI Atlas is presentation of the contents, which were collected by the UHI project partners. The data provided by the project partners consist of several data layers. They present different aspects of urban heat island phenomena and urban heat island influencing factors. The database has been regularly updated by the

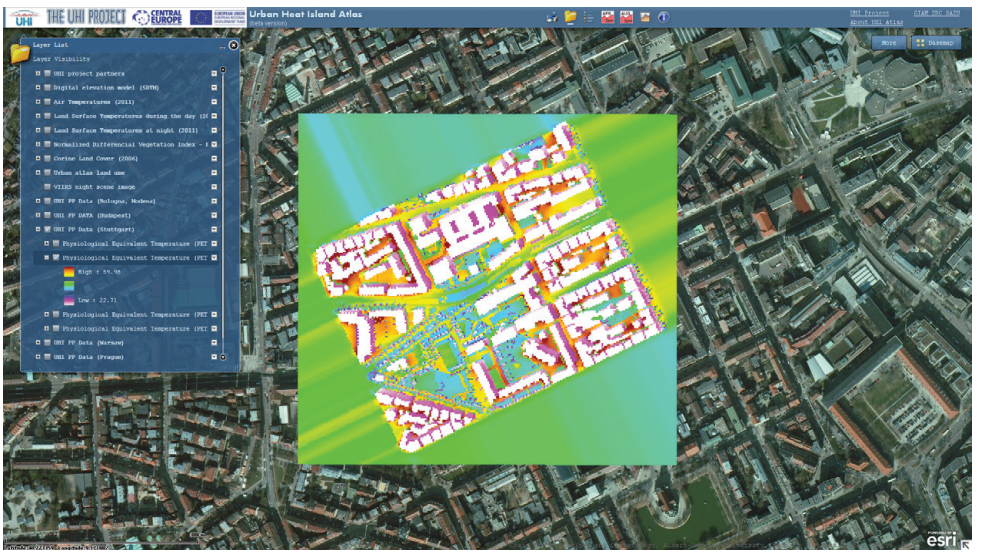

Figure 3. Print screen of Urban Heat Island Atlas – Stuttgart

Source: http://gismo.zrc-sazu.si/flexviewers/UHIAtlas/.

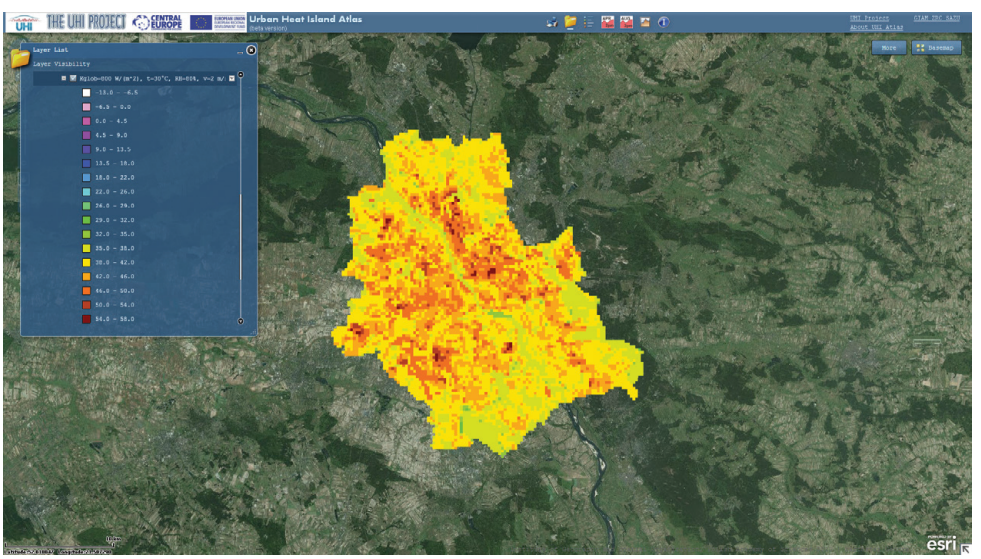

Figure 4. Print screen of Urban Heat Island Atlas – Warsaw

Source: http://gismo.zrc-sazu.si/flexviewers/UHIAtlas/.

UHI partnership and was continually updated until end of the project.

The cities of Bologna and Modena present spatial data on meteorological stations in the Bologna and Modena area, data on the air quality monitoring system in the Bologna and Modena area, a map of buildings in the municipality of Bologna and Modena, a map of pilot areas in Modena and the border of the municipalities of Bologna and Modena. Partners from Stuttgart present maps of physiological equivalent temperature (PET) for different areas in Stuttgart (Fig. 3).

Partners from Warsaw present the border of the municipality of Warsaw, IGSO measurement points, a map of UHI index in the city, a map of universal thermal climate index for Warsaw and various health resorts and a map of global solar radiation at ground level (Mazovian Lowland). As regards influencing factors, maps of reflected solar radiation (Mazovian Lowland), air temperature (Mazovian Lowland), wind velocity (Mazovian Lowland), and subjective temperature index (STI) (Mazovian Lowland) are presented (Fig. 4). The cities of Prague and Budapest provided various raster climate data.

Partners from Prague present temperature and precipitation maps for the surrounding region. Besides these maps, locations of meteorological stations with links to climographs are also available.

Partners from Budapest present various global radiation, temperature, and precipitation maps.

Editors' note:

Unless otherwise stated, the sources of tables and figures are the author(s), on the basis of their own research.

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