COLOPHONE

Title: **Central-European Urban Heat Island Atlas**

Authors: dr. Rok Ciglič (rok.ciglic@zrc-sazu.si), dr. Blaž Komac (blaz.komac@zrc-sazu.si)
(with contributions from: Regional Agency for Environment Protection in Emilia-Romagna (http://www.arpa.emr.it), Emilia Romagna Region. General Directorate Territorial and negotiated planning (http://www.regione.emilia-romagna.it/), Hungarian Meteorological Service (http://www.met.hu), Municipality of Stuttgart (http://www.stuttgart.de), Karlsruhe Institute of technology (http://imk-ifu.kit.edu), Meteorological Institute - University of Freiburg (http://www.uni-freiburg.de), Institute of Geography and Spatial Organization, Polish Academy Of Sciences (http://www.igipz.pan.pl), Charles University in Prague, Faculty of Mathematics and Physics (http://www.mff.cuni.cz), City Development authority of Prague (http://www.iprpraha.cz), Czech Hydrometeorological Institute (http://portal.chmi.cz), and Institute of anthropological and spatial studies ZRC SAZU, http://iaps.zrc-sazu.si/en).

Editor: dr. Rok Ciglič (rok.ciglic@zrc-sazu.si)
Reviewers: Paolo Lauriola, UHI project leader, Dirigente - CTR Ambiente e Salute, A.R.P.A. AG.REGIONALE PREVENZIONE AMBIENTE Emilia Romagna, Direzione Tecnica di Modena, Italy, dr. Magdalena Kuchcik, Department of Geoecology and Climatology, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Warszaw, Poland

Issued by: ZRC SAZU, Anton Melik Geographical Institute, Ljubljana, Slovenia © 2015
URL: http://www.zrc-sazu.si/en/zbirka/uhi-atlas

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

912.442:551.584.5(4-191.2-21)(0.034.2)
551.584.5(4-191.2-21)(084.42)(0.034.2)

CIGLIČ, Rok
Central-European urban heat island atlas [Elektronski vir] / [authors Rok Ciglič, Blaž Komac ; with contributions from Regional Agency for Environment Protection in Emilia-Romagna ... et al.]. - Interaktivni atlas. - Ljubljana : ZRC SAZU, 2015

Način dostopa (URL): http://gismo.zrc-sazu.si/flexviewers/UHIAtlas/

ISBN 978-961-254-860-5
1. Gl. stv. nasl. 2. Komac, Blaž
282823168

INTRODUCTION

This is the **Central-European Urban Heat Island Atlas** (CE UHI atlas). The CE UHI Atlas is a web-based tool for presentation of different factors influencing urban heat island phenomena. It is a result of the UHI project – Development and application of mitigation and adaptation strategies and measures for counteracting the global urban heat islands phenomenon. See other project results at http://eu-uhi.eu for better understanding of different factors influencing urban temperatures such as vegetation health, land use cover, and settlement density. The Atlas was elaborated in the GIS environment using ArcGIS Desktop and published online using the ArcGIS Server programme at http://www.zrc-sazu.si/en/zbirka/uhi-atlas.

DESCRIPTION

The Central-European Urban Heat Island Atlas as a tool for mitigation, risk prevention and management of the urban heat island (UHI) phenomenon.
dr. Rok Ciglič, dr. Blaž Komac

1 The UHI Atlas – an introduction

The UHI is a microclimatic phenomenon that occurs in the metropolitan areas. It is characterized by a significant increasing of temperature in the urban area with respect to the surrounding rural areas. These areas of higher temperatures are termed 'urban heat islands'. Higher temperatures induce enhanced direct and indirect heat stress leading to low quality of life in urban areas. Urban heat island affects people's health by bad air quality, while also influences water resources and energy consumption. This can be avoided by the implementation of proper knowledge, good mitigation practices, and adaptation measures. The CE UHI Atlas is a tool for considering the critical urban areas in Central Europe and can be used to limit the temperature increase in cities by establishing proper short-term and long-term mitigation, risk prevention and management activities.

2 Data layers presented in the UHI Atlas

The Atlas presents different factors influencing the urban heat island, such as elevation, vegetation status, land use, and settlement density. The atlas consists of the following digital layers:

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

The user friendly interface of the UHI Atlas enables users to select between different layers, make profiles, for example, across temperatures in Central Europe and zoom to the UHI partner data.
Elevation is presented by the NASA (National Aeronautics and Space Administration) shuttle radar topographic mission (SRTM) digital elevation data. The SRTM digital elevation model enables us to calculate various relief parameters, such as slope, aspect, and curvature. It has a resolution of 3 arc seconds, which is approximately 60x90 m in Central Europe (Jarvis et al. 2008).
Vegetation is an important urban heat island influencing factor, presented in the UHI Atlas by raster satellite data of normalized difference vegetation index – NDVI. The data in 1 km resolution cover all Central Europe, presenting examples of NDVI index for spring, summer and autumn seasons by calculated 16-day averages. The images are taken in different bands and can be downloaded at the US Geological Survey (USGS) website (NASA 2011).
Land surface temperature (LST) is tightly connected to air temperature, since the air is heated by long-wave radiation. Different examples of land surface temperatures are presented in the UHI Atlas

for spring, summer and autumn seasons, based on 8-day averages. The data clearly show differences in land surface temperature between rural and urban areas. The images are available at the USGS web site or other satellite image browsers (NASA 2011).
The atlas also presents data of **air temperature at 2 m above the ground** for various seasons in 2011. The data cover all Central Europe area. Air temperature was calculated especially for the UHI Project on the basis of MODIS Land Surface Temperature (LST) by K. Zakšek and K. Oštir, ZRC SAZU, Slovenia. The method was presented in the paper: Estimation of daily mean air temperature from MODIS LST in Alpine areas (Colombi et al. 2007).
Since **land cover** and **land use** influence microclimate, the UHI Atlas presents Corine land cover and Urban atlas, presenting data of detailed land use maps covering the area of the project cities. *Corine land cover* presents a raster dataset with 100 m resolution showing land cover in 2006. The data were produced from satellite imagery of the French SPOT-4&5, and the Indian IRS P6 satellites. The dataset is available for download at European environmental agency website (CLC ... 2012).
The *Urban atlas* 2005–2007 presents vector data of land cover in more than 300 European cities with more than 100,000 inhabitants in 1:10,000 scale. The UHI Atlas presents high-resolution land use maps for the UHI project cities: Budapest, Ljubljana, Prague, Stuttgart, Venice, Vienna, and Warsaw. The Urban atlas was provided by the European environment agency (Urban atlas 2010).
Next to the Urban atlas the densely populated areas are presented by the **night scene satellite images**. Such images can evidently expose bigger cities, and areas with intense human activity, such as industrial zones, oil rigs and highways. Images were taken by the Visible Infrared Imaging Radiometer Suite sensor (VIIRS) in 2012 with a 750 m resolution. The VIIRS sensor is a scanning radiometer that collects visible and infrared imagery and radiometric measurements of land, atmosphere, cryosphere, and oceans. Images are produced by the NASA Earth Observatory (NASA 2012).
The special part of the UHI Atlas is presentation of the contents provided by the **UHI project partners**. The data present different aspects of urban heat island phenomena and urban heat island influencing factors. The database was updated and upgraded until end of the UHI project.
The cities of Bologna and Modena present spatial maps of meteorological stations, air quality monitoring system, buildings in the municipality in the Bologna and Modena area. Pilot areas in Modena and the border of the municipalities of Bologna and Modena are also presented.
The city of Stuttgart presents maps of physiological equivalent temperature (PET) for different areas in Stuttgart.
The city of Warsaw presents the Institute of geography and spatial organization 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 for Mazovian Lowland. Maps of solar radiation, air temperature, wind velocity, and subjective temperature index (STI) are also presented.
The cities of Prague and Budapest provided various raster climate data.
The city of Prague presents temperature and precipitation maps for the surrounding region. Besides these maps, locations of meteorological stations with links to climograms are also available.
The city of Budapest presents various global radiation, temperature, and precipitation maps.

3 References

COLOMBI A., DE MICHELE C., PEPE M., RAMPINI A., 2007. Estimation of daily mean air temperature from MODIS LST in Alpine areas. EARSeL eProceedings 6, http://eproceedings.org/static/vol06_1/06_1_colombi1.pdf [2 June 2014].
CLC, 2012. Corine Land Cover 2006 raster data. The European Topic Centre on Spatial Information and Analysis, http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-2 [7 may 2014].
JARVIS A., REUTER H.I., NELSON A., GUEVARA E., 2008. Hole-filled seamless SRTM data V4. International Centre for Tropical Agriculture (CIAT), http://srtm.csi.cgiar.org [7 May 2014].

Komac, B., Ciglič, R. 2014. Urban heat island atlas: a web tool for the determination and mitigation of Urban Heat Island effects. Geographia Polonica 87-4. Internet: https://www.geographiapolonica.pl/article/item/9534.html
NASA, 2011. NASA Land Processes Distributed Active Archive Center (LP DAAC). MODIS data USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota.
NASA, 2012. Earth at night. NASA Earth obser- vatory, http://earthobservatory.nasa.gov/Features/NightLights/page3.php [2 June 2014].
URBAN ATLAS, 2010. Directorate-General Enter- prise and Industry. http://www.eea.europa.eu/data-and-maps/data/urban-atlas [2 June 2014].

DESCRIPTION OF LAYERS

Air temperature for different situations in 2011 is presented in this layer. Air temperature was calculated by Klemen Zakšek and Krištof Oštir. There are air temperatures for one 8-day average in April, August and September. Temperatures are available for 2am, 10am, 2pm and 10 pm. Input data layers are MODIS land surface temperatures. For the MODIS data see:
https://lpdaac.usgs.gov/products/modis_products_table
For the method of determination of air temperature see:
http://eproceedings.org/static/vol06_1/06_1_colombi1.pdf

Digital elevation model SRTM was derived from the USGS/NASA SRTM data. Citation: Jarvis A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available from http://srtm.csi.cgiar.org.

The layer of **Land surface temperature during the day** is presented by the MODIS product. The level-3 MODIS global Land Surface Temperature (LST) and Emissivity 8-day data are composed from the daily 1-kilometer LST product (MOD11A1&MYD11A1) and stored on a 1-km Sinusoidal grid as the average values of clear-sky LSTs during an 8-day period. MOD11A2 & MYD11A2 are comprised of daytime and nighttime LSTs, quality assessment, observation times, view angles, bits of clear sky days and nights, and emissivities estimated in Bands 31 and 32 from land cover types. (LPDAAC website)
More: https://lpdaac.usgs.gov/products/modis_products_table
Where to find it: http://earthexplorer.usgs.gov/ and other image browsers
How to cite: https://lpdaac.usgs.gov/about/citing_lp_daac_and_data

Land surface temperature during the night is presented by the MODIS product. The level-3 MODIS global Land Surface Temperature (LST) and Emissivity 8-day data are composed from the daily 1-kilometer LST product (MOD11A1&MYD11A1) and stored on a 1-km Sinusoidal grid as the average values of clear-sky LSTs during an 8-day period. MOD11A2 & MYD11A2 are comprised of daytime and nighttime LSTs, quality assessment, observation times, view angles, bits of clear sky days and nights, and emissivities estimated in Bands 31 and 32 from land cover types. (LPDAAC website)
More: https://lpdaac.usgs.gov/products/modis_products_table
Where to find it: http://earthexplorer.usgs.gov/ and other image browsers
How to cite: https://lpdaac.usgs.gov/about/citing_lp_daac_and_data

Normalized difference vegetation index (NDVI) in resolution 1 km is used to present the vegetation. It is used for global monitoring of vegetation conditions and is used in products displaying land cover and land cover changes. These data may be used as input for modeling global biogeochemical and hydrologic processes and global and regional climate. These data also may be used for characterizing land surface biophysical properties and processes, including primary production and land cover conversion. Global MYD13A2 data are provided every 16 days at 1-kilometer spatial resolution as a gridded level-3 product in the Sinusoidal projection. VI production is phased between Terra and Aqua

acquisitions, with Terra beginning on Day 001 and Aqua beginning on Day 008. MODIS has also variety of other products. The images are taken in different bands. (LPDAAC website)
More: https://lpdaac.usgs.gov/products/modis_products_table
Where to find it: http://earthexplorer.usgs.gov/ and other image browsers
How to cite: https://lpdaac.usgs.gov/about/citing_lp_daac_and_data

Corine Land Cover 2006 presents numerous land cover types (at 100 m resolution). Two kinds of satellites provided imagery for CLC2006 project: French SPOT-4&5 (60 km swath width, 20 m pixels; VIS, NIR and SWIR bands), and Indian IRS P6 (141 km swath width, 23 m pixels; VIS, NIR and SWIR bands).
Data sources: The European Topic Centre on Spatial Information and Analysis.
Date of delivery: April 2012
Data owners: European Environment Agency Copyright holder: European Environment Agency (EEA)

The European Urban Atlas is part of the local component of the GMES land monitoring services. It provides reliable, inter-comparable, high-resolution land use maps for 305 Large Urban Zones and their surroundings (more than 100.000 inhabitants as defined by the Urban Audit) for the reference year 2006. The GIS data can be downloaded together with a map for each urban area covered and a report with the metadata.
Where to find it: European Environment Agency (http://www.eea.europa.eu/data-and-maps/data/urban-atlas)

The night scene image was taken by Sensor VIIRS. VIIRS, a scanning radiometer, collects visible and infrared imagery and radiometric measurements of the land, atmosphere, cryosphere, and oceans. It extends and improves upon a series of measurements initiated by the Advanced Very High Resolution Radiometer (AVHRR) and the Moderate Resolution Imaging Spectroradiometer (MODIS). VIIRS data is used to measure cloud and aerosol properties, ocean color, sea and land surface temperature, ice motion and temperature, fires, and Earth's albedo. Climatologists use VIIRS data to improve our understanding of global climate change. (NASA website). The resolution of the data layer is 750 m. Temporal coverage: 2012.
More: http://npp.gsfc.nasa.gov/viirs.html
Where to find it: http://earthobservatory.nasa.gov/Features/NightLights/page3.php
Credit: NASA's Earth Observatory, NASA

Project partner data sets

Italian data
This data is provided by UHI Project Partners from Bologna and Modena: Regional Agency for Environment Protection in Emilia-Romagna (http://www.arpa.emr.it/) and Emilia Romagna Region, General Directorate Territorial and negotiated planning (http://www.regione.emilia-romagna.it/).

Hungarian data
Variation of main climate elements between 2011-2013 over Hungary are presented by the Hungarian Meteorological Service (http://www.met.hu/).

German data
Physiological Equivalent Temperature (PET) for different parts of Stuttgart is presented by the Municipality of Stuttgart (http://www.stuttgart.de/), the Karlsruhe Institute of technology (http://imk-ifu.kit.edu/), and the Meteorological Institute, University of Freiburg (http://www.uni-freiburg.de/).

Polish data
This database was provided by the UHI Project partner from Warsaw, the Institute of Geography and Spatial Organization, Polish Academy Of Sciences (http://www.igipz.pan.pl/).

Czech data
This data package presents temperature and precipitation raster maps for Prague area.
There are also locations of meteorological stations in Prague and its vicinity with links to the climate data graphs. This data were provided by the Charles University in Prague, Faculty of Mathematics and Physics (http://www.mff.cuni.cz/), the City Development authority of Prague (http://www.iprpraha.cz/), and the Czech Hydrometeorological Institute (http://portal.chmi.cz/).

DISCLAIMER

The **UHI project** has provided this data as advisory and indicative and specifically and exclusively for the purpose of information and education. All facts, figures, concepts and principals provided relate only to the UHI project. They may be inaccurate, out of date and subject to revision without notice. The data provided (or any derivative thereof) can be used in whole or in part for any project, by referring to the source. Do not rely upon any information found in the UHI atlas without an independent verification.

ACKNOWLEDGEMENT

The authors acknowledge financial support from the ***EU CENTRAL EUROPE*** *Interreg Programme* co-financed by the *ERDF* and the Slovenian Research Agency research core funding Geography of Slovenia (P6-0101). The Central-European Urban Heat Island Atlas was produced by the *Anton Melik Geographical Institute ZRC SAZU, © 2015*.