STUDYING THE COHERENCE VALUES FOR UHI: A CASE STUDY OF IASI

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Abstract: *Thermal properties of surface, Earth’s surface energy balance and atmospheric conditions effect the land surface dramatically. Local and global change continues in the Earth’s climate since the industrial era continues. The urban heat island (UHI) represents the phenomenon of higher atmospheric and surface temperatures occurring in urban area or metropolitan area than in the surrounding rural zones due to urbanization. UHI is most noticeable during the summer and winter. The main cause of the UHI effect is from the modification of land surfaces. In this research was using MODIS and SENTINEL data. From SENTINEL images was extracted coherence maps to determine values of this parameter in areas where UHI was notice. Coherence for SUHI range from 0.20 to 0.89 for day and varies for night between 0.23-0.89.*

Keywords: *MODIS, SENTINEL, UHI, coherence*

1. INTRODUCTION

LST (Land surface temperature) can provide crucial information about the climate and the properties of physical surface, which plays a role in many environmental processes [3, 16].

The accelerated urbanization has led to a substantial increase in the number of urban population worldwide and led to the significant development of UHI (Urban Heat Island). Natural landscape was transformed to an impervious surface due to the rapid and important growth of urban areas that was result in the diminution of green cover and, consequently, an intensification and development in LST [2, 9].

The urban heat island (UHI), according to Voogt et al. (2005) describes the "episode" (phenomenon) of higher atmospheric and surface temperatures occurring in urban zone and/or metropolitan zone than in the surrounding rural zones due to urbanization. The Surface of urban heat island (SUHI) depends on impervious surfaces, variation of vegetation cover and climatic conditions like season, wind and rainfall. Occurrence of UHI is one attribute of the transformation of the nature lands from urban areas into impervious built-up lands. That process had an important impacts on the ecosystem, biodiversity, hydrologic system and local climate [12]. LST, acording to numerous researches [10, 11], is as parameter for detecting UHI phenomenon. While surface temperatures is used as both higher and more variable than concomitant air temperatures due to the complexity of the different land surface classes in urban environments and variations in urban topography [13, 15]. The mainly reason of the UHI is the increase of artificial environments which has led to the important changes of land use (LU) and land cover (LC), creates a great amount of anthropogenic waste heat, and in consequences in a series of changes in the urban environment [8].

An important approach to urban heat island research was the development of remote sensing technology. In earlier thermal remote sensing researches, much weight has been placed on using NDVI as the mainly indicator of urban climate. Remotely sensed (RS) data of LST, LU/LC and other surface characteristics have been widely used to study UHI phenomenon [1, 6, 7; 16]. The mainly advantages of using RS data are the availability of high resolution, consistent and repetitive coverage and capability of measurements of earth surface conditions [1].

Coherence is the fixed relationship between waves in a beam of electromagnetic (EM) radiation. Two wave trains of EM radiation are coherent when they are in phase. That is, they vibrate in unison. In terms of the application to things like radar, the term coherence is also used to describe systems that preserve the phase of the received signal [17].

2. MATERIAL AND METHODS

2.1. Study Area

Study Area (fig.1) is geographically situated on latitude 47°12'N to 47°06'N and longitude 27°32'E to 27°40'E. Iași is the seat of Iași County and the largest city in eastern Romania, the capital of the historical region of Moldavia. Iași is positioned on the Bahlui River, affluent of Jijia that flows into the Prut River. Summer is hot and it lasts from the end of the month of May up to the half of September. Autumn is a short season, of transition. In the second half of November there is usually frost and snow. Winter is a freezing season with temperatures dropping to –20ºC [19].

FIG.1. Study Area [20]

2.2. R.S. Data

2.2.1. Modis Data

The MOD11A1 product provides daily perpixel Land Surface Temperature (LST) with 1 kilometer (km) spatial resolution in a 1,200 by 1,200 km grid. The pixel temperature value is derived from the MOD11_L2 swath product. Above 30 degrees latitude, some pixels may have multiple observations where the criteria for clear-sky are met. When this occurs, the pixel value is a result of the average of all qualifying observations [18]. In this paper were used MYD11A1, for day time, and MYD11A1, for night time.

2.2.2. Sentinel Data

Sentinel SAR has a dual polarisation radar. Sentinel system can transmit a signal and receive him in both polarisation vertical (VV) and horizontal (HH). Dual polarisation SAR products covering complex values and inter-channel phase informations allow for measurement of the polarisation properties of terrain moreover to the backscatter that can be measured with one polarisation [17]. In this paper was used Sentinel SAR sata, with SLC product type, IW sensor mode for period 01.01.2017-31.12.2018.

2.3. Data Processing

Modis data, MOD11A1 and MYD11A1, for day and night time was process in ArcMAP. Was select just images that had a clear sky.

Based on a network of sensors (fig.2) for monitoring ground-level temperatures on period 01.01.2013-31.12.2018 were selected, days which the temperature exceeded 35 °C (tab.1), respectively 25° C during the night (tab.2).

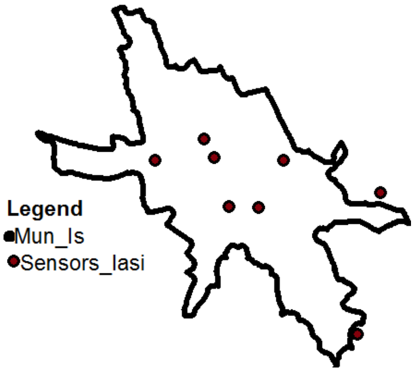

FIG.2. Network of sensors

Table 1. distribution of day selected

Nr. crt.	Year	Month					total
		may	june	july	august	september	
1	2013	2	3	5	11	0	21
2	2014	1	3	4	10	3	21
3	2015	0	7	13	18	6	44
4	2016	0	6	12	10	10	38
5	2017	0	5	5	17	4	31
6	2018	9	5	3	19	4	40

Table 2. distribution of night selected

Nr. crt.	Year	Month					total
		may	june	july	august	september	
1	2013	0	0	0	2	0	2
2	2014	0	1	0	4	2	7
3	2015	0	0	7	7	5	19
4	2016	0	6	8	3	1	18
5	2017	0	1	2	9	1	13
6	2018	6	0	2	9	2	19

To create maps coherence were used SNAP and ArcMAP. For period 2017-2018 was taken Sentinel SAR images for ascendent and descendent position.

3. RESLUTS AND DISCUSSION

3.1. LST Statistics

For earth and environmental studies, land surface temperature is now considered as very important parameter. Figure 3 show LST maps for period 2013-2018 for selected days and table 3 show statistical data of LST.

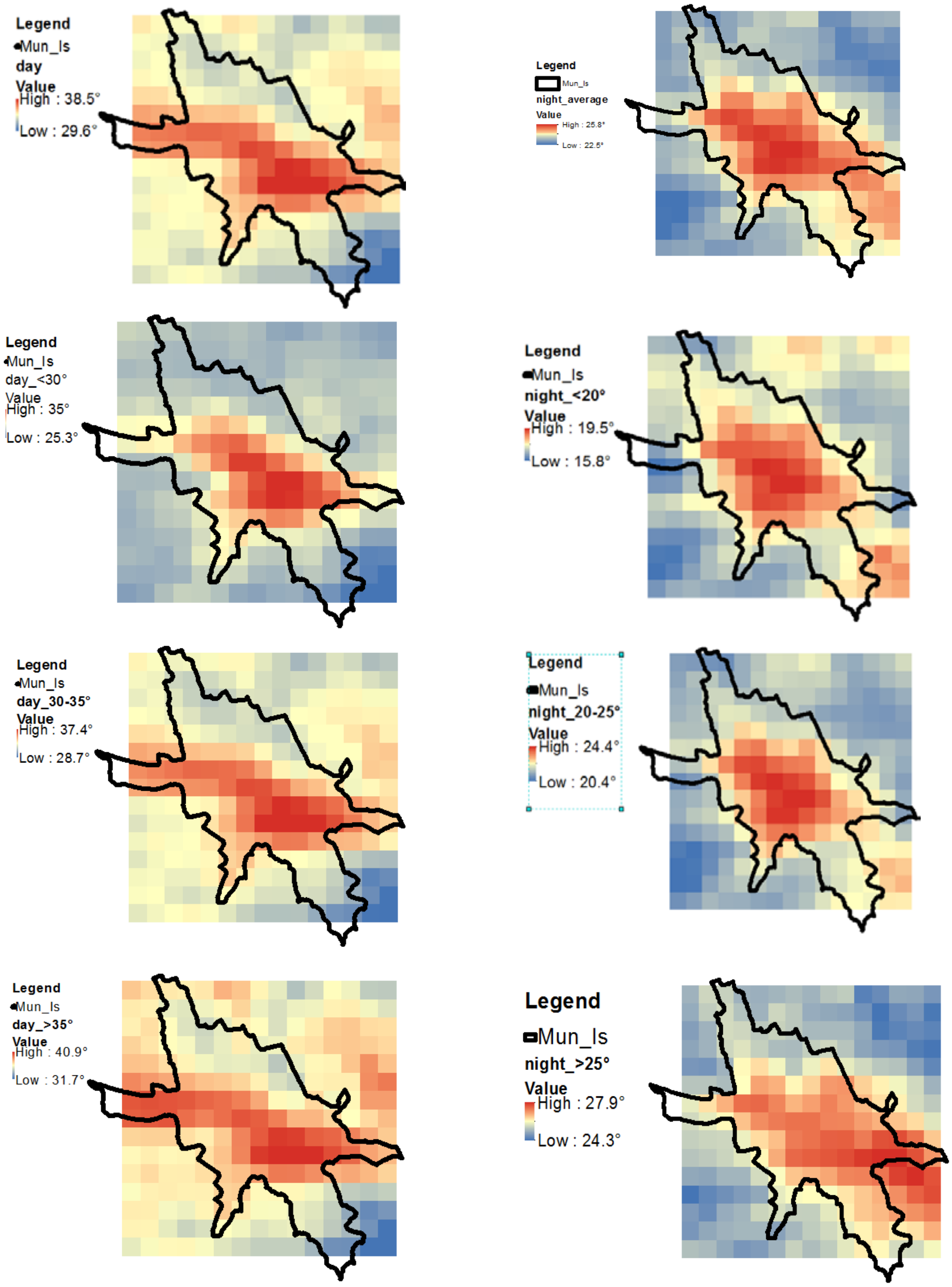

FIG.3. LST maps

Table 4. Statistics data-LST

Nr. crt.	Mode	Minimum (°C)	Maximum (°C)	Variations (°C)	Mean (°C)	Standard deviation
1	DAY	38.5	29.6	8.9	34.1	1.468
2	NIGHT	25.8	22.5	3.3	24	0.825
3	NIGHT <20°C	19.5	15.8	3.7	17.4	0.794
4	NIGHT 20-25°C	24.4	20.4	4	22	0.816
5	NIGHT >25°C	27.9	24.3	3.6	25.9	0.887
6	DAY <30°C	35	25.3	9.7	29.1	1.927
7	DAY 30-35°C	37.4	28.7	8.7	33	1.425
8	DAY >35°C	40.9	31.7	9.2	36.7	1.488

Mean and variations are the parameters with an significant importance. These two parameters reflect change extent of the LST. The mean value for study area for days selected, where MODIS images was available, for 2013-2018 period was 24°C for night time and 34.1°C for day time. The variation is more significant during the day time, 8.9°C, comparative with night time, 3.3°C.

3.2. Coherence Data

Coherence represents the fixed relationship between waves in a beam of EM (electromagnetic) radiation. When two wave trains of EM radiation are in phase they are coherent (Feretti et al. 2000 & 2007).

Coherence value range between 0 and 1. A interferogram has a good coherence if value is over 0.6. Coherence values between 0 and 0.3 indicate presence of vegetation and water.

Figure 4 show coherence maps for period 2017-2018 for images that was taken in ascendent and descendent position.

Table 4 shows statistical data for coherence maps for study area, Iasi city, for period 2017-2018.

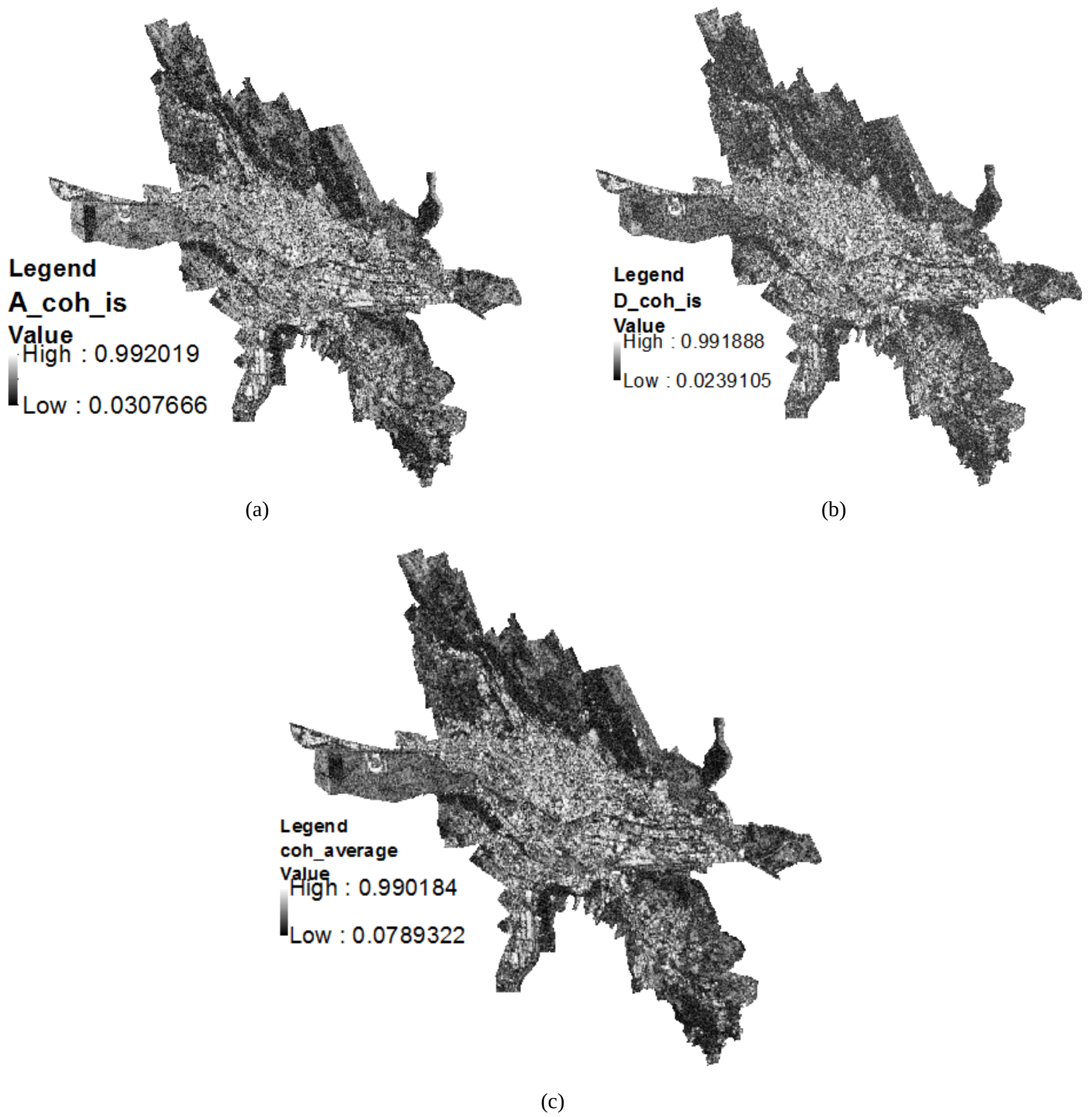

FIG.4. Coherence maps: a - Ascendent position; b - Descendent position; c - Mean coherence map

Table 4. Statistics data-coherence

Nr. crt.	Coherence map	Minimum	Maximum	Mean	Standard Deviation
1	Ascendent	0.030	0.992	0.487	0.19
2	Descendent	0.023	0.991	0.418	0.18
3	Average	0.079	0.990	0.453	0.17

It can be seen from the statistical data and the coherence maps that the study area presents for large areas values below 0.3 for the parameter determined from the Sentinel images.

3.3. Discussion

From LST maps for day and night time was extracted zones with temperature over 35°C respectively 25°C that indicate SUHI. For these areas, the coherence values were extracted. Maps for these processes are show at figure 5, and data statistics for coherence is found at table 5.

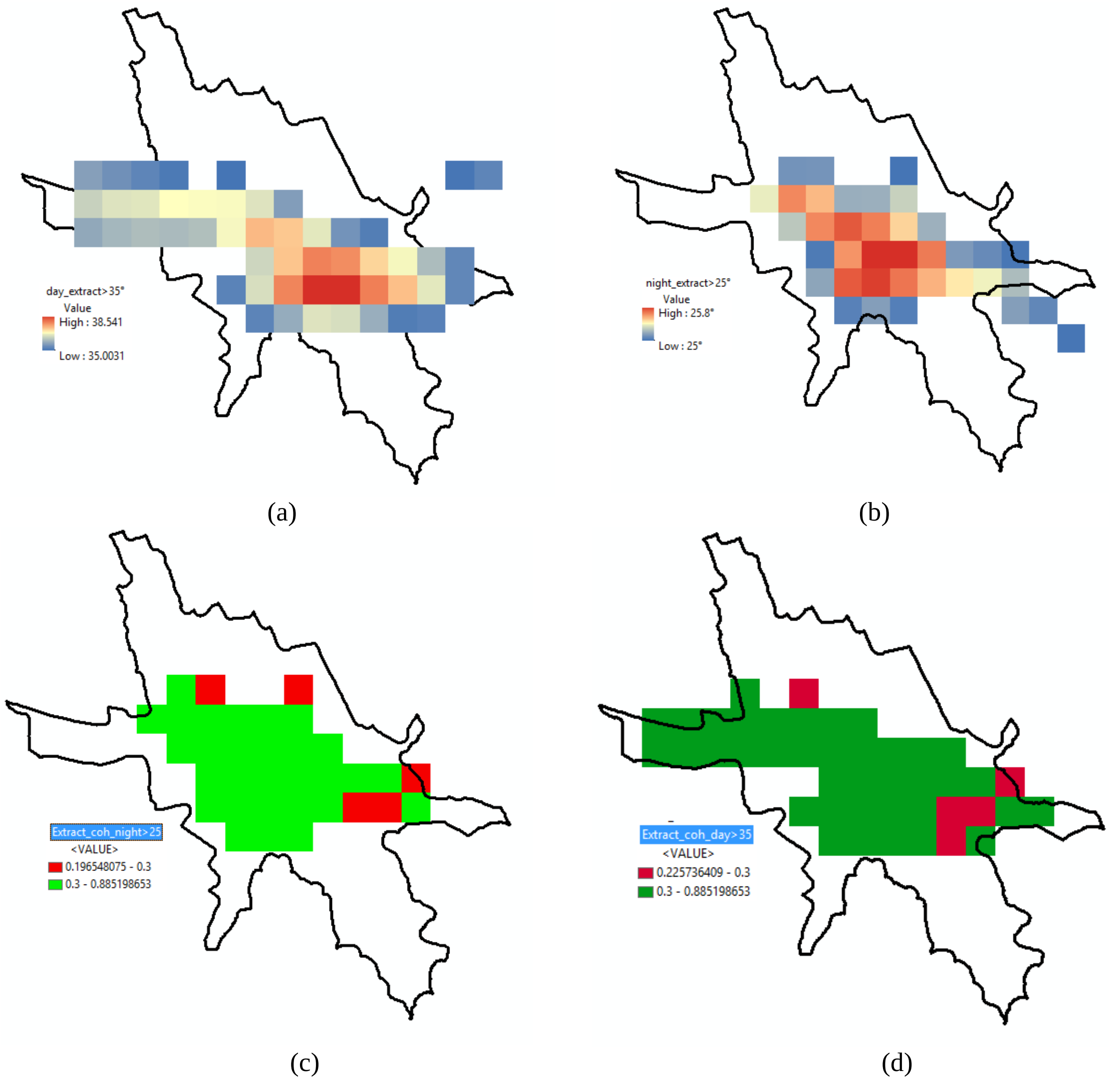

FIG. 5. LST map extract: a – Day map; b – Night map;
c - Coherence night extract; d - Coherence day extract

Table 5. Coherence data statistics-SUHI

Nr. crt.	Type	Minimum	Maximum	Mean
1	Night	0.23	0.89	0.54
2	Day	0.20	0.89	0.55

The parameter "mean" has high value, over 0.5, that indicate study area presents highly built-up area. SUHI is usually detected in built-up areas of cities, therefore coherence values confirmed that.

The increase of the built-up areas and the reduction of the green spaces in the study area lately can be an explanation for the constant increase of the temperatures and the extension of the UHI.

4. CONCLUSIONS

UHI represents the phenomenon of higher atmospheric and surface temperatures occurring in urban areas than in the surrounding rural zones due to urbanization. Coherence could be used to detect areas where this phenomenon could occur.

Consistency could be used to detect areas where this phenomenon could occur. However, without monitoring the temperature of terrestrial surfaces performed with satellite technology and temperature monitoring with ground sensors, it is difficult to determine the magnitude of the UHI.

5. REFERENCES

[1] Carlson T., Gillies R., Perry M., 1994, *A method to make use of thermal infrared temperature and NDVI measurements to infer surface soil water content and fractional vegetation cover;*

[2] Choi, Lee, Byun, 2012, *Determining the effect of green spaces on urban heat distribution using satellite imagery*, Asian J. Atmos. Environ;

[3] Dousset B., Gourmelon F., 2003, *Satellite multi-sensor data analysis of urban surface temperatures and land-cover;*

[4] Ferretti A., C. Prati C., Rocca F., (2000), *Nonlinear subsidence rate estimation using permanent scatterers in differential SAR interferometry,* IEEE Trans. Geosci. Remote Sensing, vol. 38, no. 5, pp. 2202–2212;

[5] Ferretti A., Monti-Guarnieri A., Prati C., Rocca F., (2007), *Guidelines for SAR Interferometry Processing and Interpretation*, ESA Publications;

[6] Gallo K., Owen W., 1999, *Satellite-based adjustments for UHI temperature bias*, Journal of Applied Meteorology, 806−813;

[7] Gallo K.., McNab L., Karl T., Brown J., Hood J., Tarpley J., 1993, *The use of NOAA AVHRR data for assessment of the UHI effect*, Journal of Applied Meteorology;

[8] Huang S., Taniguchi M., Yamano M., Wang C., 2009, *Detecting urbanization effects on surface and subsurface thermal environment—A case study of Osaka*, Sci. Total Environ;

[9] Kumar, P Bhaskar, K. Padmakumari, 2012, *Estimation of LST to study UHI effect using Landsat ETM+ imag;.*

[10] Li Sheng, Xiaolu Tang, Heyuan You, Qing Gu, Hao Hu, *Comparison of the urban heat island intensity quantified by using air temperature and Landsat land surface temperature in Hangzhou*, China, Ecological Indicators, Volume 72, 2017, Pages 738-746;

[11] Macarof, Paul and F. Stătescu. "*Comparasion of NDBI and NDVI as Indicators of Surface Urban Heat Island Effect in Landsat 8 Imagery: A Case Study of Iasi.*" Present Environment and Sustainable Development 11 (2017): 141 – 150;

[12] Matamyo Simwanda ,Manjula Ranagalage, Ronald C., Estoque, Yuji Murayama, *Spatial Analysis of Surface Urban Heat Islands in Four Rapidly Growing African Cities Remote Sens*. 2019, 11(14), 1645;

[13] Nichol J., 1996, *High resolution surface temperature patterns related to urban morphology in a tropical city: a satellite-based study*, J, of Ap. Meteorology;

[14] Scott J. McGrane (2016) *Impacts of urbanisation on hydrological and water quality dynamics, and urban water management: a review,* Hydrological Sciences Journal, 61:13, 2295-2311;

[15] Streutker D., 2002, *A remote sensing study of UHI of Houston, Texas, Int. Journal of Remote Sensing*;

[16] Weng Q., Dengsheng L., Jacquelyn Sh., 2004, *Estimation of LST–vegetation abundance relationship for UHI, Remote Sensing of Environment*, 89, 467−483;

[17]*** www.esa.int;

[18]*** www.usgs.gov;

[19]*** https://en.wikivoyage.org/wiki/Iași;

[20]***https://en.wikipedia.org/wiki/Iași.