Night-time Earth Remote Sensing Data as a Source for Monitoring Territorial Dynamics

Vladimíra Šilhánková[13], Michael Pondělíček[13], Jan Langr[2], Jan Kamenický[2], Pavel Struha[13]

Abstract**—**The key spatial process that is currently under way in Europe is the process of urbanization. However, this process has several stages dependant on the socio-economic conditions in the relevant territory. So far we have been missing an objective and politically as well as "professionally" uninfluenceable and independent instrument at regional and local levels which would allow the monitoring of individual urbanizing and development processes thus objectively ascertaining the status of changes in the territory. The article introduces the possibilities of utilisation of night-time remote sensing data for measuring and monitoring territorial changes or more precisely for measuring changes at the regional and local levels – the so-called territorial dynamics indicator. The territorial dynamics indicator consists of two sub-indicators, namely a) the trend of light intensity development over time and b) the value of the year-on-year change in the light intensity (increases or decreases).

Keywords**—**economic grow indicator, Earth Remote Sensing Data, night light intensity measurement, urban dynamic

I. Introduction

The key spatial process that is currently under way in Europe is the process of urbanization. However, this process has several stages dependant on the socio-economic conditions in the relevant territory. Next to social and economic cohesion, territorial cohesion represents another dimension of cohesion. Territorial cohesion contributes to the improvement of the competitive ability of the territory, promotes the enhancement of the living conditions of residents and thereby increases the quality of the environment. The task which lies ahead is to ensure long-term results employing differentiated policies.

The mission of regional policies in general is to ensure the mutual balance between individual areas and territories of the selected land unit. So far we have been missing an objective and politically as well as "professionally" uninfluenceable instrument, which would allow the transparent monitoring of individual urbanizing processes thus objectively ascertaining the status of changes in the territory development, i.e. a viable instrument for measuring territorial dynamics over time.

The currently missing instrument would enable the measuring of the real process of urbanization – territorial dynamics over time thus gaining adequate source data for regional policies as well as territorial and strategic planning at all relevant levels, that is to say not only the national and regional, but also on the levels of micro-regions and localities that can influence these processes via their policies. The instrument-indicator that may assess, in a simple manner, the complex of spatial development, structural issues, spatial opportunities, as well as the spatial consequences of the policies of the CR and regions is the presented "territorial dynamics indicator". The territorial dynamics indicator setup and measuring based on the Earth remote sensing data provide an objective and independent instrument for planning authorities, where it clearly and impartially describes the status of the territorial change at the level of municipalities, districts, regions as well as the whole of the CR over time. This indicator should be a key bearer of political messages about the advancement of the implementation and results of the spatial cohesion policies – decrease of territorial disparities in the CR.

Within the scope of various researches it has emerged that the performance of economies in the steady environment of the market-oriented economies of North America can be reliably measured via the development of the intensity and extent of the night-time illumination of the regions. Currently, hand in hand with the spreading of similar types of research, a number of other measurable variables have surfaced along with the possible influences on regional development, which are reflected in the night-time light intensity. Furthermore, the article contains a presentation of how it is possible to make use of the night-time light changes for the monitoring of the efficiency and functioning of regional development support policies in the Czech Republic as an integral part of the European space. [4,5]

II. Objective and Methods

The objective of the article is to introduce the methodology of measuring and monitoring territorial changes (territorial dynamics indicator) as an instrument for monitoring and measuring the development of territorial disparities and urbanisation over time.

The task of the thesis was to find a mechanism for measuring the territorial dynamics – speed of the urbanization (land claim) of the so-far non-urbanized areas and the degree

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[1]Civitas per Populi, o.p.s., Střelecká 574/13, 500 02 Hradec Králové, Czech Republic, civitasperpopuli@gmail.com

[2]T-MAPY spol. s r.o.,Špitálská 150/10,500 03 Hradec Králové, Czech Republic, jan.kamenicky@tmapy.cz, jan.langr@tmapy.cz

[3]Department of Regional Development, College of Regional Development, Žalanského 68/54,163 00 Prague, Czech Republic, vladimira.silhankova@vsrr.cz, michael.pondelicek@vsrr.cz

of use of the already urbanized area, as the source data for the evaluation of the development and economic efficiency of the given territory or more precisely the measuring of regional disparities. The methodology work proceeded from the assumption that a territory developing in a balanced (permanently sustainable) manner uses evenly the as-of-yet not utilised areas and areas urbanized before for its development. In this context it is possible, in essence, to construe the "permanently sustainable" territorial dynamics as the balanced use of the previously urbanised areas with a certain share of development in the so-far non-urbanized territory. Moreover, the proposed territorial dynamics indicator sets the "ranges / borders" between the sustainable and non-sustainable development of the territory and the differences between individual regions, both as an immediate comparison and a comparison over time.

III. Data Pre-processing

Within the analysis of the availability of data for monitoring changes in the territory applying the Earth remote sensing (ERS) the available sources of night-time images (NTL) for the territory of the Czech Republic were looked into. The only suitable existing source was the data set – DMSP Version 4 DMSP-OLS Nighttime Lights Time Series, which provides the time series of images from the period of 1992–2013. However, the individual data sets acquired in an annual periodicity from several sensors (F-10, F-12, F-14, F-15, F-16 and F-18) have not been mutually calibrated and therefore it is not possible to make a comparison either of data from several sensors for one year or a year-on-year comparison.

National Geophysical Data Center (NGDC) Earth Observation Group (EOG) under the National Oceanic and Atmospheric Administration (NOAA) specialises in taking and processing night-time light images (NightTime Lights – NTL). One of the current satellite sensors gathering global night-time light data is the U. S. Air Force Defence Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). The EOG group started processing the DMSP data in 1994 and acquired the time series of annual cloud-free composite night-time images from the DMSP night-time images taken during the period 1992–2013 (and still continues doing so).

The OLS system placed on the DMSP program satellites has a unique feature, which is the ability to detect night illumination of a very low intensity on much of the populated areas of the surface of the Earth. These data are stored in the NOAA NGDC. In the visible and near-infrared (VNIR) portion of the electromagnetic spectrum the OLS sensor is capable of detecting radiation approximately one million times weaker than most of the existing satellite systems. During the 14 orbits in the course of one day each of the satellites will record data about radiation emitted from each spot on the surface of the Earth at the extent of latitude 75° north and 65° south of the Equator, within the time span of 20:30–22:00 hours. By using the NTL at the point of the new moon of the lunar cycle it is possible to eliminate a number of natural light sources connected with sunlight or moonlight. Subsequently, in a manual or semi-automatic manner, applying frequency filters one can eliminate other undesirable light radiation sources (e.g. aurora, fires, laser light sources). Moreover, the observations influenced by cloud cover are also excluded from the source data. The OLS system can detect illumination up to the threshold level of: 5.10^{-10} $W.cm^{-2}.sr^{-1}$, which allows the detection of sources of artificial light in urbanized as well as less- urbanized areas. OLS sensors take measurements from a height of approximately 830 km above the surface of the Earth and the spatial resolution of the acquired data comes to about 2.7 km. OLS sensors have dynamic ranges of 6 bits, that means they can register the intensity of the incident radiation at the range of the values 0–63. These values are referred to as the digital numbers (DN).

As a result of an analysis of all of the suitable DMSP images, the data product - DMSP Version 4 DMSP-OLS Night-time Lights Time Series (V4 DMSP-OLS NTL) was generated, representing a time series of annual cloud-free composite night-time images taken during the period of 1992–2013. In the course of this period NTL were taken by sensors on a total of 6 satellites (F-10, F-12, F14, F-15, F-16 and F-18). In some years NTL were taken concurrently by two sensors. Annual composites were made from the taken NTL, obviously separately for each sensor. The composites are of the shape of a geographic grid with pixels of 30'' × 30'' in dimensions (on the Equator it corresponds to the area of approximately 0.86 km^2, within the Czech Republic it is about 0.55 km^2), where the value of each cell of the 0–63 range is an average of the values of the overlapping pixels of all suitable cloud-free source images taken by the sensor in question in the given year. The data set also contains a metadata file describing a number of observations for each pixel of the annual composite included in the calculation.

Tab. 1 Available annual composite images of the V4 DMSP-OLS NTL product

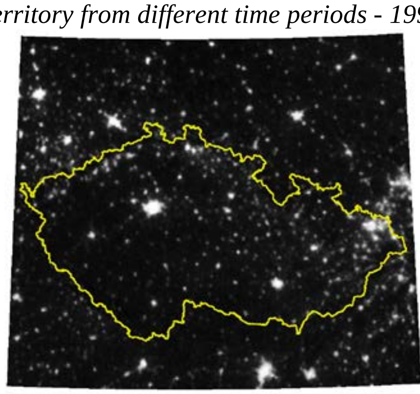
Year / satelite	F-10	F-12	F-14	F-15	F-16	F-18
1992	F101992					
1993	F101993					
1994	F101994	F121994				
1995		F121995				
1996		F12199				

		6				
1997		F121997	F141997			
1998		F121998	F141998			
1999		F121999	F141999			
2000			F142000	F152000		
2001			F142001	F152001		
2002			F142002	F152002		
2003			F142003	F152003		
2004				F152004	F162004	
2005				F152005	F162005	
2006				F152006	F162006	
2007				F152007	F162007	
2008					F162008	
2009					F162009	
2010						F182010
2011						F182011
2012						F182012
2013						F182013

Source: http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html

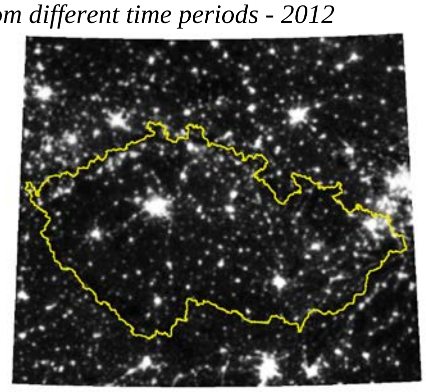
The chosen source is the data product – Global annual cloud-free night-time lights composite, which is available in the form of annual composites in the time period of 1992–2013 for all years and from all of the available satellites. [1,6,8,9]

Fig. 1 Visual comparison of 2 composite images of the same territory from different time periods - 1992



Source: Own processing from [8]

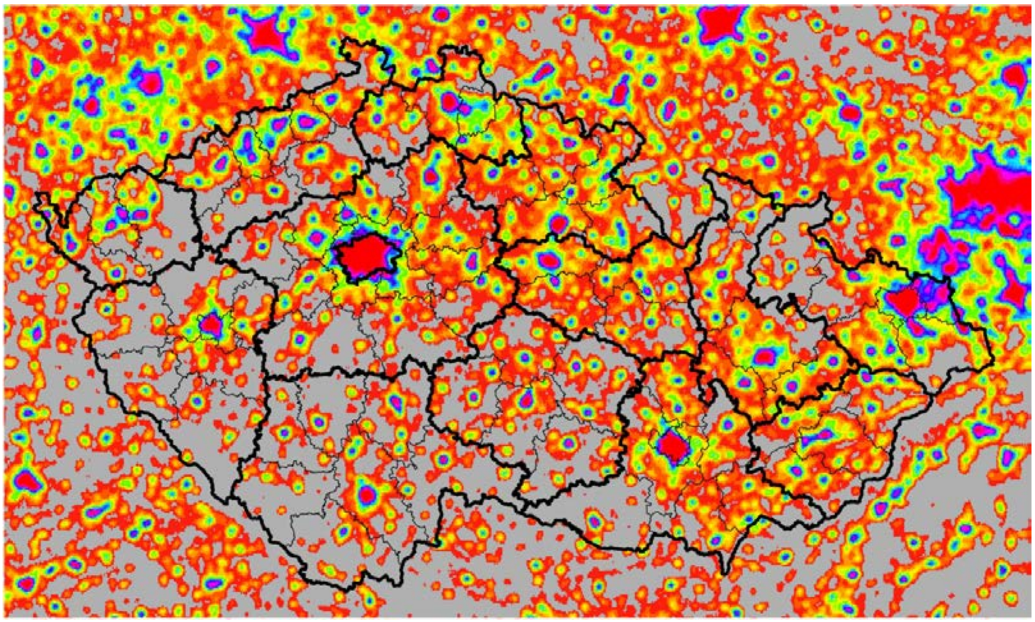
Fig. 2 Visual comparison of 2 composite images of the same territory from different time periods - 2012



Source: Own processing from [8]

The light values in the night-time image data are not absolute values, but they represent a relative scale of values in the 0–63 range (referred to as the DN – digital number) corresponding to the light intensity at any researched place in the given year. This light intensity figure of the selected place is calculated from all of the relevant measurements taken in the course of a calendar year. The metadata file analysis shows that in most of the cases the number of relevant observations is sufficient and that the calculated DN values may be considered to be credible and therefore applicable for the territorial dynamics research in question.

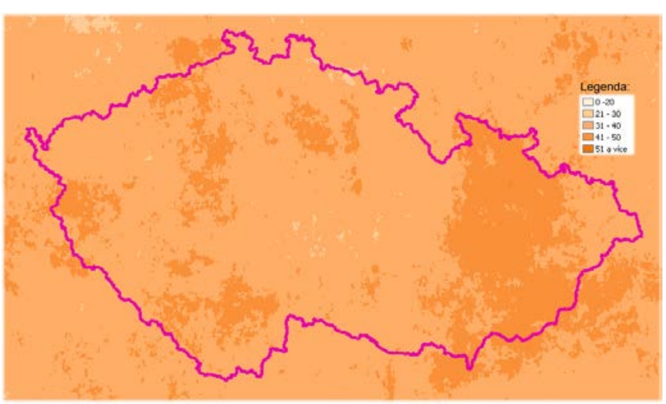
Fig. 3 Data of the F182012 annual composite in the uncontrolled classification (grey colour for DN 0–6)



Source: Own processing from [8]

By a mere visual evaluation of the image it is obvious that the distribution of light intensity within the Czech Republic is considerably differentiated and possibly also in a way other than we could imagine if we just proceeded from elementary geographic knowledge. It is the spatial distribution of the light values and the change of this distribution over a time period within the studied territory that is one of the basic cornerstones of the research, which brings a principal added value when compared with the socio-economic indicators that are aggregated for statistical units where the internal differentiation is missing, is not available or not easily expressed.

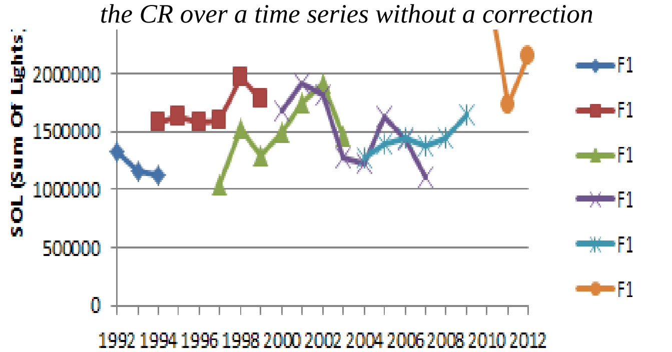
Fig. 4 Metadata file of the F182012 annual composite (the value in the legend refers to the number of observations included in the calculation)



Source: Own processing from [8]

In the course of the work an analysis of all available annual composites (summarised images) for the territory of the Czech Republic was performed, encompassing 34 composites taken by six satellites within the period of 1992–2013.

Graph 1 Comparison of annual composites for the territory of the CR over a time series without a correction

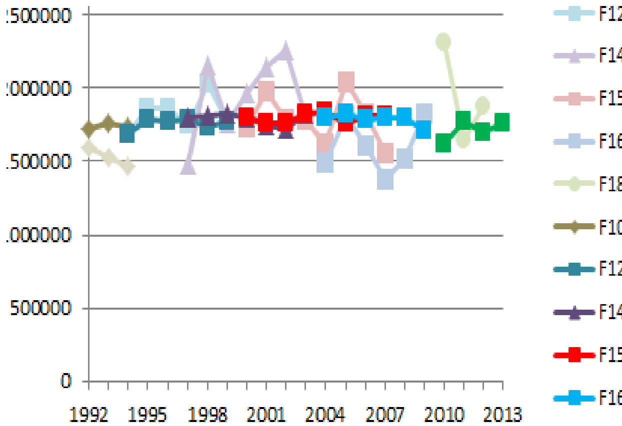


Source: Own processing from [8

On the basis of the acquired knowledge the recommended radiometric data correction at the extent of the Czech Republic was carried out applying the general transformation keys.[2,3] However, the result of the radiometric correction is not satisfactory and has not brought about the possibility of the relevant comparison of data in individual sets within the time series.

During the phase of the source data analysis for the pilot study on the utilisation of night-time composite images from satellites, the analytical derivation of own transformation keys – specific for the territory of the Czech Republic was conducted. Applying the radiometric calibration of the annual composites (the so-called intercalibration) the radiometric equalization of images from various sensors in different years was achieved at the same radiometric level. Only at this stage is it possible to carry out the relevant monitoring of the long-term trend in the night-time light development in the territory of the Czech Republic.

Graph 2 Comparison of annual composites for the territory of the CR over a time series with a general and the author's own correction



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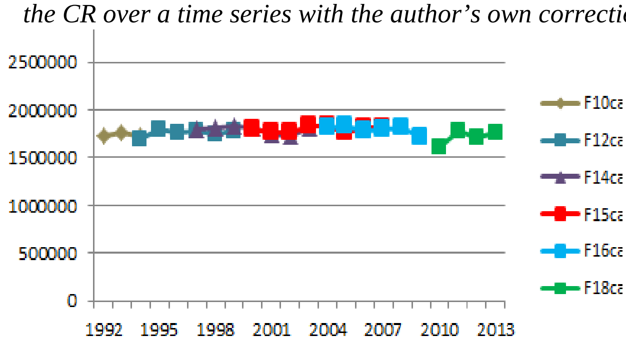
urce: Own processing from [8]

Graph 3 Comparison of annual composites for the territory of the CR over a time series with the author's own correction



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Source: Own processing from [8]

The method applied for the analytical derivation of own transformation keys was the automatic intercalibration with robust regression published by Xi Li & col. – Automatic intercalibration of night-time light imagery using robust regression.[10] The method applied was modified by using the polynomial regression function of the second-order model (quadratic model) instead of the linear regression function. The correctness of the said transformation was corroborated by the fact that the differences in the Sum of Lights (SOL) values for the territory of the Czech Republic acquired in one year from more sensors were successfully minimised as a result of the performed transformation (see Graph 2).

Data with radiometric correction conducted on the basis of these transformation keys have been used for the determination of the indicator for the relevant year for the selected territorial units. These territorial units may be regions, districts, municipalities with extended competence (MEC) or municipalities. For comparison purposes it is possible to choose the relevant territorial units also in a different manner, e.g. by demarcating units of the same area size.

IV. Future of the Night-time Light Imagery

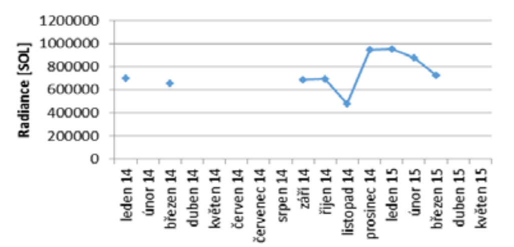
Nightsat represents a concept for a satellite system capable of global observation of the location, form and density of lighted infrastructure and development within human settlements at the level of medium spatial resolution. [2] Such a satellite system should be able to produce complex global cloud-free light maps on a yearly basis. Nightsat should collect data from the near-synchronous orbit in early evening hours with the spatial resolution of 50 to 100 meters and detection limit of $2.5.10^{-10}$ $W.cm^{-2}.sr^{-1}.\mu m^{-1}$ or better.

Imperfections of the existing DMSP-OLS system include particularly the coarse spatial resolution, the missing on-board calibration, limited dynamic range (6 bit), saturation in the urban agglomeration centres and absence of a thermal band suitable for fire detection.

The DMSP-OLS project is followed up by the project of Visible/Infrared Imager/Radiometer Suite (VIIRS), whose sensors are located on the satellite system –National Polar-orbiting Operational Environmental Satellite System (NPOESS). The VIIRS system will ensure the collection of night-time light images of very low intenzity with the improved spatial resolution (pixel 742 m), wider dynamic range, increase in the number of spectral bands to 22 and the on-board calibration. Compared with the DMSP-OLS the sensing time span is shifted to the time span around midnight local time.

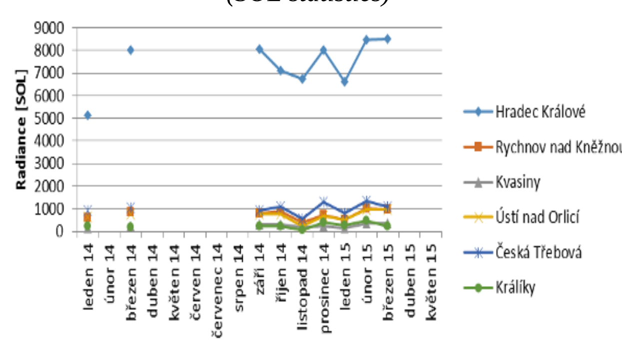
In 2012 and 2013 a test run of the VIIRS project (beta version) took place. Currently, it is possible to download monthly composite data of the Version 1 Nighttime VIIRS Day/Night Band Composites product for the period from January 2014. The upgraded version of the product and follow-up products are to follow. Data are supplied in the form of a geographic grid with the pixel dimensions of 15'' × 15'', which corresponds on the Equator to the area of approximately 0.22 km^2, within the Czech Republic it is about 0.14 km^2. Thanks to the on-board calibration the data are expressed directly in the units of physical quantity radiance, i.e. in $nW.cm^{-2}.sr^{-1}$ (nanoWatt/cm^2/steradian).

Graph 4 Night-time light data from the VIIRS source (SOL statistics) in the Czech Republic



Source: Own processing

Graph 5 Night-time Light Data from the VIIRS Source (SOL statistics)



Source: Own processing

V. Preconditions for Setting the Territorial Dynamics Indicator from the RSS Data

The territorial dynamics indicator proceeds from the monitoring of development trends of current (and inimitable) characteristics of night-time light in the researched selected territory over time. The basic monitoring time interval is a calendar year, which means all the data are correlated to this time interval. Annual sequences then allow the comparison of the night-time light characteristics in the researched territory year-on-year, between any two randomly selected years or throughout the whole chosen period – as necessary, depending on the way we wish to compare the characteristics.

In analysing the night-time imagery data in the researched territory, the Zonal Statistics method is applied to the radiometrically equalized annual composites in the raster format, calculating for the individual defined zones (municipal polygons, MEC, districts or regions) the statistics of the DN values for pixels spatially belonging to the relevant zone. The important statistics of each zone include the number of pixels (Count), the mean value (Mean) and the sum of the values (Sum), referred to as the Sum of Lights (SOL). If the objective is to compare the night-time light data with the socio-economic characteristics (e.g. population figures or GDP), then the Sum of Lights (SOL) statistics will be applied. If we wish to take into consideration the spatial extent of the zone in our comparison, we will use the Mean statistics for it (since it corresponds to the mean value of the night-time light intensity in the researched zone).

The DN values for individual researched territories are dependant on the degree of the urbanization of the land. That means that the highly urbanized areas will have the established DN values higher than in less urbanized areas with a high share of non-urbanized land such as forests, bodies of water, fields or pasture land. In order to be able to mutually compare change dynamics in the corresponding territorial units (e.g. municipalities), it is suitable, for comparison purposes, to eliminate the influence of large-sized non-urbanized land which form parts of these territorial units. These areas have very low DN values and if included in the study, they may significantly distort the characteristics under comparison. The influence of the urbanization density may in such a case be limited by making the assumption that the sum of the DN values in the non-urbanized part of the territory has only an insignificant share in the SOL value of the selected zone. For comparison we will use the Mean value adjusted by the share of the urbanized area size in the overall area of the zone. The value calculated in this way corresponds to the mean value of the light intensity of the urbanized part of the studied territory.

Data demonstrating the representation of the urbanized area at the level of municipalities can be obtained from the statistics of ULS – Urban and Local Statistics provided by the Czech Statistical Office.

Tab. 2 Division of land into urbanized and non-urbanized areas

Arable land	*Non-urbanized*
Hop fields	*Non-urbanized*
Vineyard	*Non-urbanized*
Gardens	***Urbanized***
Orchards	*Non-urbanized*
Permanent grasslands	*Non-urbanized*
Agricultural land	*Non-urbanized*
Woodland	*Non-urbanized*
Water areas	*Non-urbanized*
Built-up areas	***Urbanized***
Other areas	***Urbanized***

Source: [7]

The ULS time series allows studying development of the share of urbanized and non- urbanized areas in each individual municipality.

VI. Structure of the Territorial Dynamics Indicator from the RSS Data

The territorial dynamics indicator for the researched territory consists of two sub-indicators:

a) The trend of light intensity development over time;
b) The value of the year-on-year change in the light intensity (increases or decreases).

A) <u>The trend of light intensity development over time</u>

This sub-indicator is expressed with the Graph of the light intensity development trend of one or more researched territories in the monitored time period. The values on the “y" axis represent the mean value of light in the studied territory (Mean statistic) expressed by the dimensionless quantity DN and correspond to the overall light in the researched territory (Sum of Lights – SOL statistic) standardised by the area size of the researched territory.

The values on the “y" axis do not take into consideration the degree of urbanization of the researched territory (i.e. the share of the urbanized zone in the total area size of the researched territory), therefore this sub-indicator does not serve for the direct comparison of the characteristics of several researched territories. Nonetheless, it can be used for comparing the development trend of several researched territories. The comparison may include aggregated data for the higher administrative units (MEC, district, region, Czech Republic).

B) <u>The value of the year-on-year change in the light intensity (increases or decreases)</u>

This sub-indicator is expressed with the Graph of the year-on-year change of one or more researched territories in the monitored time period. The values on the “y" axis represent the value of the year-on-year change of the mean value of the light in the researched territory. The value of the year-on-year change in the given year is calculated as a quotient of the change of the mean value of the light in the given year and in the previous year and the mean value of the light in the previous year expressed in percent, i.e. representing a proportional increase or decrease in the given year compared with the previous year.

This sub-indicator does not serve for the direct comparison of the characteristics of several researched territories. Nonetheless, it can be used for comparing the year-on-year change trend of several researched territories. The comparison may include aggregated data for the higher administrative units (MEC, district, region, Czech Republic).

The sub-indicator does not reflect the distribution of the year-on-year change in light intensity within the researched territory.

The area of the Graph is divided horizontally into sections that correspond to sub-indicator evaluation categories on a five-point scale. The "+" value represents a reasonable and sustainable territorial development. The "0" value symbolizes a stable territory. The "-" value represents stagnation or a slight decline. The "++" value symbolizes an unhealthily fast, dynamic development of the territory. The "- -" value represents regression (decline) of the territory. The "++" and "--" value requires intervention or a different solution – measure in the territory, whether of an incentive nature in the instance of the "- -" values or of a decelerating nature in the case of the "++" value.

Subsequently, the proposed indicator evaluates the change dynamics and the shift in emphasis in the focus of the development in the territory by measuring the night-time light intensity. The indicator enables the monitoring of the territorial stability trends on a long-term basis as well as evaluating various other developmental characteristics and year-on-year changes.

VII. Pilot Study

Certain areas have been chosen for the preparation of the pilot study, namely the territory of the Hradec Králové and Pardubice Regions, at the level of districts and regions with reference cases going as low as to the level of municipalities. For the pilot verification at the level of municipalities, the following have been selected - Hradec Králové, Kvasiny and Rychnov nad Kněžnou in the Hradec Králové Region and Česká Třebová, Králíky and Ústí nad Orlicí in the Pardubice Region.

The night-time images and other spatially localised data were processed using the commercial SW – ArcGIS for Desktop of the Esri company. Statistical calculations as well as table and graph creations were made in the Microsoft Excel SW from the MS Office package.

The pilot study encompassed an analysis of the time series of radiometrically equalized night-time images of the DMSP Version 4 DMSP-OLS Nightime Lights Time Series product for the time period of 1992–2013 for the territory of the Czech Republic focusing on the area of the Hradec Králové and Pardubice Regions. All the annual composite raster images were subjected in the ArcGIS for Desktop environment to the Zonal Statistics method, which calculated, for the individual defined zones (municipal polygons, districts and regions), the statistics of the DN values for pixels spatially belonging to the relevant zone. Moreover, for each zone the number of pixels (Count), the mean value (Mean) and the sum of the values (Sum), referred to as the Sum of Lights (SOL) were calculated. Subsequently, the statistical data were counted for the aggregated zone of the whole of the Czech Republic.

The acquired statistical data for the defined zones at the level of the administrative territory of a municipality, district and region of the pilot area were put into tables for individual levels separately for the Mean and SOL statistics.

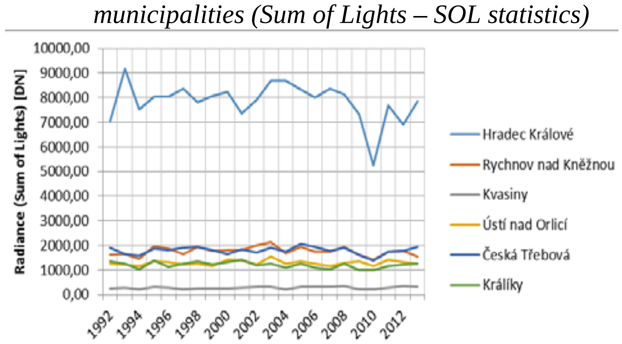
Tab. 3 Values of the Mean statistics for districts in 1992–2013

NAZOK	COUNT	1992	1993	1994	...	2010	2011	2012	2013
Chrudim	1791	12,29	12,67	12,92		12,07	12,00	11,72	11,72
Hradec Králové	1611	15,33	17,98	16,04		15,99	16,58	16,75	15,95
Jičín	1622	11,84	11,46	10,80		11,98	12,00	12,82	11,58
Náchod	1558	14,65	14,13	12,49		13,51	14,03	15,34	13,18
Pardubice	1595	15,22	18,05	17,98		17,16	17,57	17,96	17,33
Rychnov nad Kněžnou	1786	13,68	12,87	10,74		12,16	12,78	12,92	11,58
Svitavy	2474	12,89	11,26	11,55		9,92	10,25	10,69	10,14
Trutnov	2092	15,76	15,80	12,07		12,62	15,33	15,51	15,30
Ústí nad Orlicí	2285	14,44	13,24	12,52		11,96	12,80	13,64	12,85

Source: Own construction

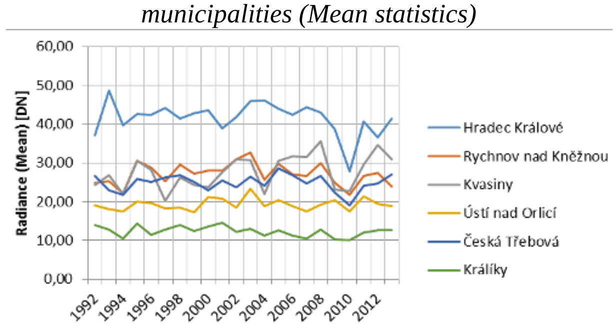
Additional tables were compiled, specifically tables demonstrating the year-on-year changes for the Mean and SOL statistics as well as the urbanization degree value of the land for selected municipalities in 2001–2013. Graphs were made from the completed tables for the defined sub-indicators of the territorial dynamics indicator relating to the pilot area. For the evaluation of the year-on-year dynamics of night-time light changes, graphs for the Mean statistics (having the same values as the SOL statistics) were prepared. The development trend was assessed first at the level of municipalities and subsequently the aggregated data for the districts and regions within the pilot territory were evaluated.

Graph 6 Trend of night-time light development in selected municipalities (Sum of Lights – SOL statistics)



Source: Own construction

Graph 7 Trend of night-time light development for selected municipalities (Mean statistics)

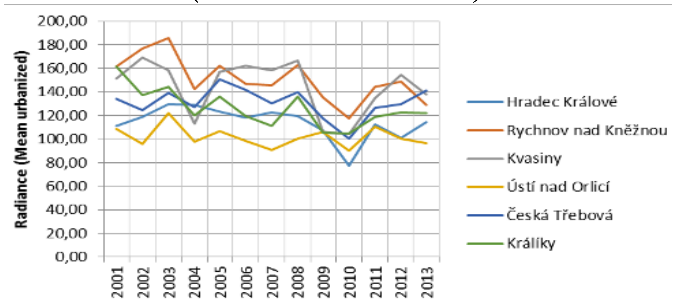


Source: Own construction

The graph shows a clear decline in light intensity in all researched municipalities with the record low in 2010, which is probably connected with the impacts of economic recession on real life in individual municipalities.

Moreover, the Mean characteristics were compared with the Mean characteristics adjusted for the share of the urbanized area in the overall area of the administrative territory of the municipality. The value calculated in this way corresponds to the mean value of the light intensity of the urbanized land of the researched territory and may be used for a more precise comparison of the areas under evaluation.

Graph 8 Trend of night-time light development for selected municipalities in 2001–2013
(Mean urbanized statistics)



Source: Own construction

Year-on-year Change in the Light Intensity

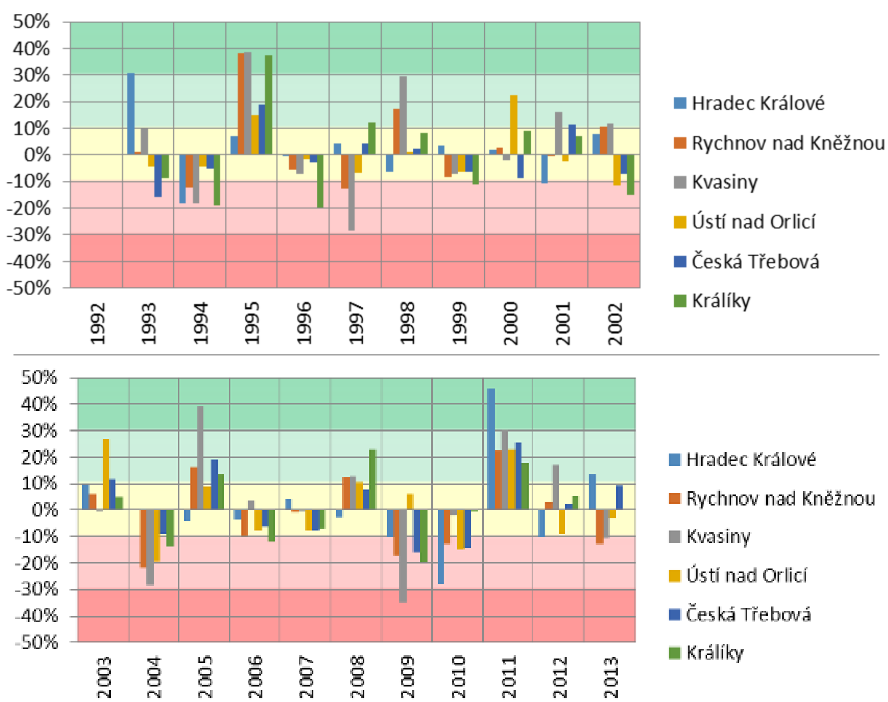
From the point of view of the possibilities of evaluation, the value of the year-on-year change in the light intensity is the key sub-indicator. The Mean statistics was applied to deduce increases and decreases, but the SOL statistics gives identical results.

The obtained graphs contain a five-point scale for a simple evaluation of the aub-indicator. The scale has been expressed with coloured background ranging from red (--), light red (-), yellow (0), to light green (+) and green (++). The meaning of the scale values is described in Chapter 3.4 Methodology.

The year-on-year change was evaluated first at the level of municipalities, then the aggregated data for the districts and regions within the pilot territory were evaluated.

The year-on-year change in the light intensity may be evaluated either separately for an individual zone (municipality, district, region), for an individual zone with aggregated data of the higher units or jointly for more researched areas.

Graph 9 The year-on-year change in night-time light for selected municipalities



Source: Own construction

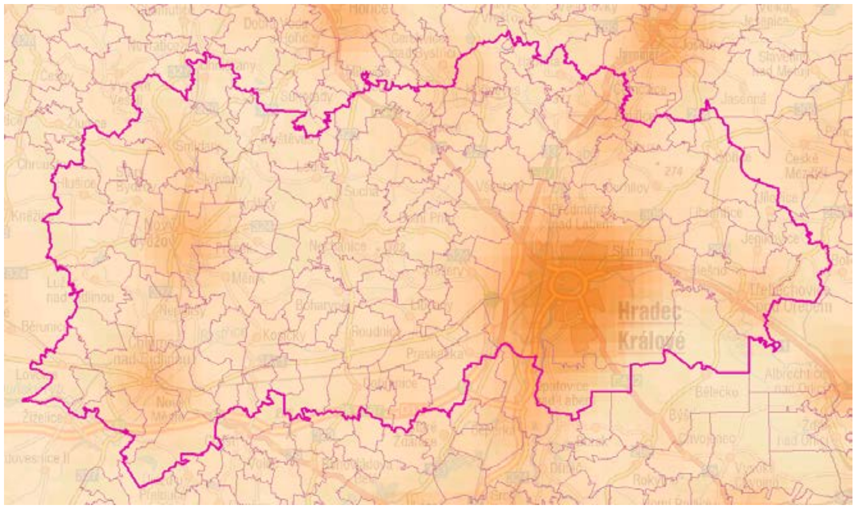
The graph clearly demonstrates the different light stability of individual regions within the monitored period.

Spatial Light Distribution

The possibility of depicting the spatial distribution (spread) of the continuous variable in the territory brings an entirely new dimension into the evaluation process. We made use of this fact for the night-time image analysis. The spatial data served for statistical evaluation of the defined areas. Since in the instance of night-time light it concerns the continuous variable (that is to say the variable which has no borders demarcating the occurrence of the acquired discrete values, but changes continually within the whole of the territory), we can utilise this fact to map out night-time light distribution within the area and its clear depiction in the map.

For one thing we can display the light distribution in the continuous form via suitable visualisation of night-time images applying the controlled classification method. This form will preserve the picture of the spatial distribution of light regardless of the demarcation of the researched zones. Subsequently, it is possible to differentiate the varied night-time light intensity inside the zones with the sufficient contrast between the urbanized and non-urbanized parts of the zone. Comparing more images of the time series it is feasible to observe the differentiated development of localities within the defined zones.

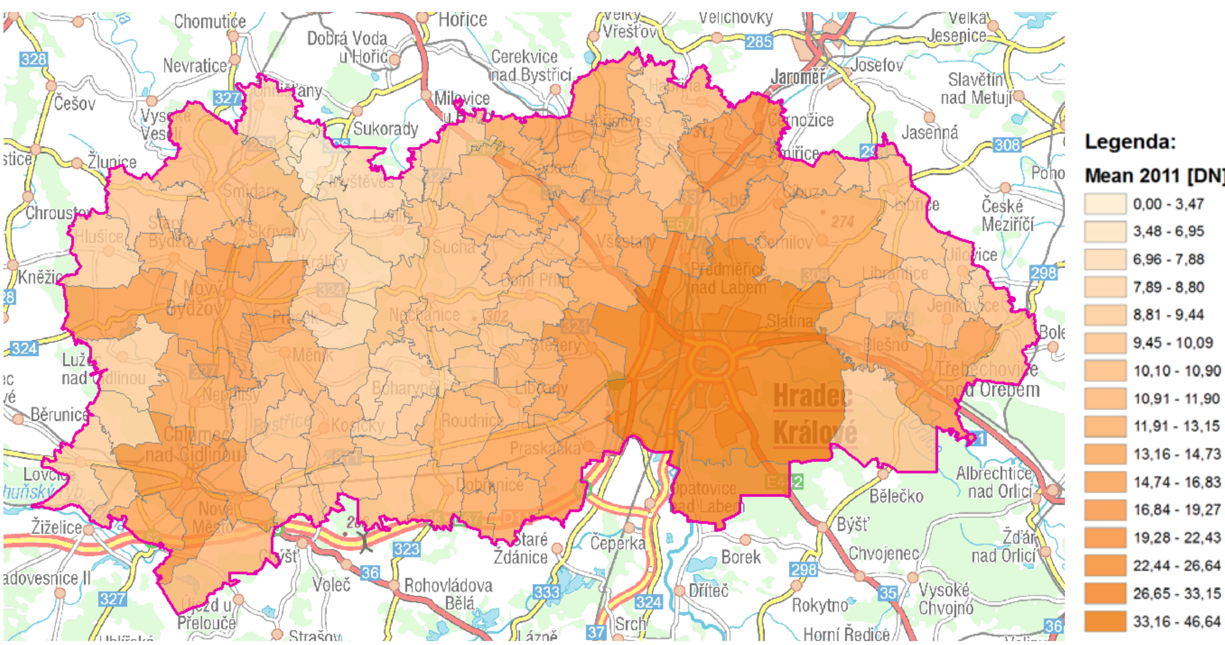
Fig. 5 Light distribution in the municipalities of the Hradec Králové District in 2011 (image F182011) – visualisation via the uncontrolled classification method (intensity corresponds to the shade)



Source: Own construction

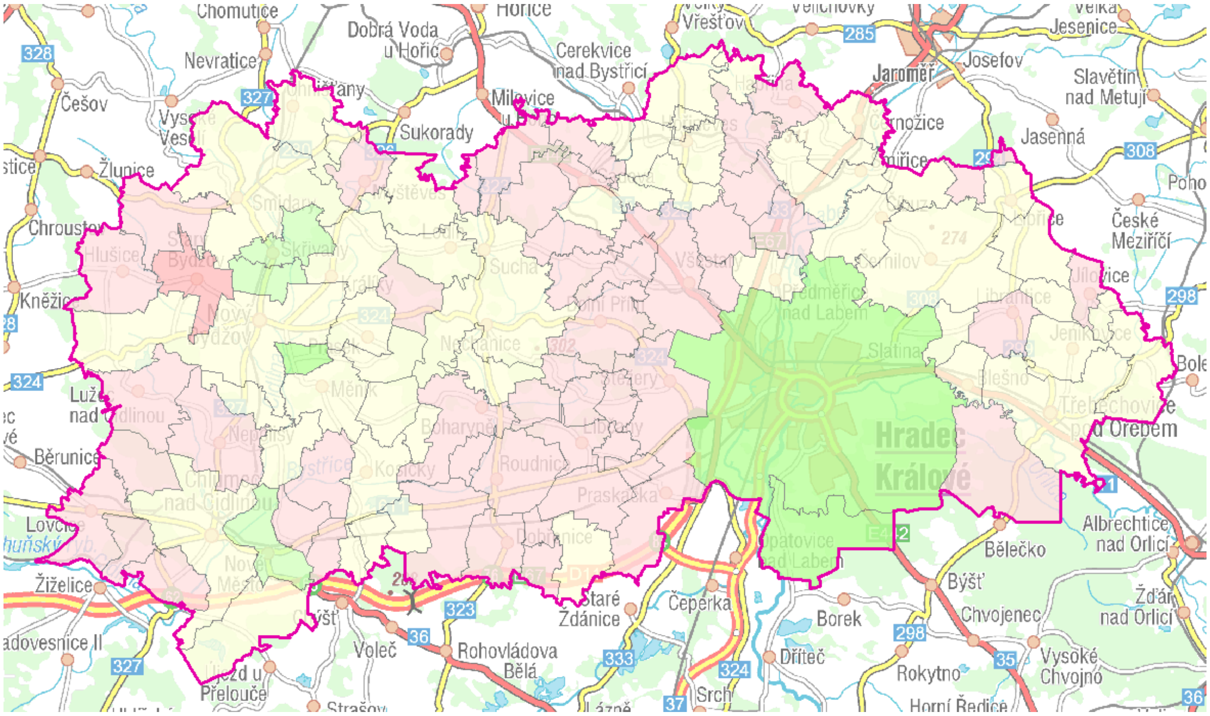
Moreover, we can depict the light distribution in a discreet form, when individual zones are visualised in the map applying one of the characteristics that were calculated for individual zones. In this instance we will display the result using the cartogram or possibly cartodiagram method.

Fig. 6 Light distribution in the municipalities of the Hradec Králové District in 2011 (image F182011) – visualisation of the Mean statistics via the cartogram method (intensity corresponds to the shade) – method of intervals – Graduated colors, classification method – Natural Breaks, 16 classes



Source: Own construction

Fig. 7 Distribution of light change in the municipalities of the Hradec Králové District in 2011 (image F182011) – visualisation of the statistic via the cartogram method (the degree of change corresponds to the shade subject to the definition of the value of the year-on-year change in the light intensity sub-indicator) – method of intervals – Graduated colours, classification method – Manual, 5 classes



Source: Own construction

The picture clearly shows that the municipality of Hradec Králové recorded a significant increase in light intensity in 2011 which can be explained by the recovery after the overcome economic recession where in other municipalities of the district the prevailing response is different (stagnation or slight decline).

VIII. Conclusion

Proceeding from knowledge and experience in the monitoring of economic and geographic development of selected areas of North America (North American Free Trade Agreement – NAFTA) the above described method offers an exact and measurable identification of the characteristics of the territorial development dynamics within the Czech Republic. The research and calibration of night-time satellite images of Europe and the creation of their composites resulted in the stabilization of the graphic expression of changes in a way enabling the possibility of comparing the monitoring on a year-on-year basis and capturing particularly the real change dynamics in the territory. The proposed and researched method predominantly on local and inter-regional levels will allow comparing the impact of regional growth support and enable the reduction of disparities on the basis of exact and genuine development data.

The presented methodology is innovative for the territory of the EU particularly in the following terms:

– It generates an instrument for setting up the monitoring and preparing the territorial dynamics database on inter-regional, micro-regional as well as local levels from independent RSS data,

– It generates an instrument for the independent monitoring of real (genuine and truthful) impacts of developmental policies and territorial planning on the area on inter-regional, micro-regional as well as local levels.

For the monitoring and measuring of the territorial disparity development and urbanization advancements over time it will be possible to measure, thanks to the generated indicator, regional differences subject to the unified methodology and it will be feasible to better monitor the impacts and performance of developmental policies, with an overlap into territorial planning. Proceeding from the results of the night-time light monitoring conducted by the means and methods of the RSS, it will be possible, from the point of view of the CR, to respond to the objectively discovered negative changes in the distribution of economic and political development by employing new policies and territorial strategies.

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