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Patterns of Changes in Brightness of Nighttime Lights in the Former USSR Territory

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ALEXANDER TROUSSOV

Dr. Alexander Troussov is Director of the International Research Laboratory for Mathematical Methods for Social Network Mining at the Russian Presidential Academy of National Economy and Public Administration (RANEPA) and Head of the Earth Remote Sensing Unit at RANEPA. Former Chief Scientist of IBM Dublin Center for Advanced Studies (2000-2013), one of the creators of the major IBM linguistic technology LanguageWare, and leader of IBM team participation in the three-year integrated 6th framework EU project NEPOMUK (development of a social semantic desktop), he has published more than 40 peer reviewed journal and conference papers and has 8 patents.

His research interests include data mining, earth remote sensing, natural language processing and social networks algorithms.

1

ALEXANDER TROUSSOV

- 2014- : Director of the International Research Laboratory for Mathematical Methods for Social Network Mining at RANEPA
- 2000-2013: IBM
  - Architect of IBM LanguageWare
  - Chief Scientist of IBM Dublin Center for Advanced Studies
  - EU Projects

  See http://atroussov.com/
- National Geophysical Data Center, Boulder, CO, USA - Visiting scientist
  - Earth Remote Sensing, numerical databases
- Observatoire de la Côte d'Azur, Nice, France – Visiting scientist
  - Numerical simulation of turbulence
- Institute of Physics of the Earth (Russian Academy of Sciences) and the International Institute for Earthquake Prediction Theory and Mathematical Geophysics, Moscow, Russia – Lead Researcher
  - R&D in geophysics and geoinformatics
- Ph.D. in Pure mathematics from Lomonosov Moscow State University

Chernobyl 1999

EU-UNESCO workshop, organised within the EU funded project for Support for Telematics Applications Cooperation with the Commonwealth of Independent States (STACCIS)

In this photo you can see Alexander Troussov (STACCIS telematics application engineer, first from the left), Jean Bonnin (Professor of Louis Pasteur University in Strasbourg) and other scientists near the sarcophagus covering the destroyed Chernobyl nuclear reactor.

Analysis of Spatiotemporal Patterns of Changes in Brightness of Nighttime Lights (NTL) in the Former USSR Territory

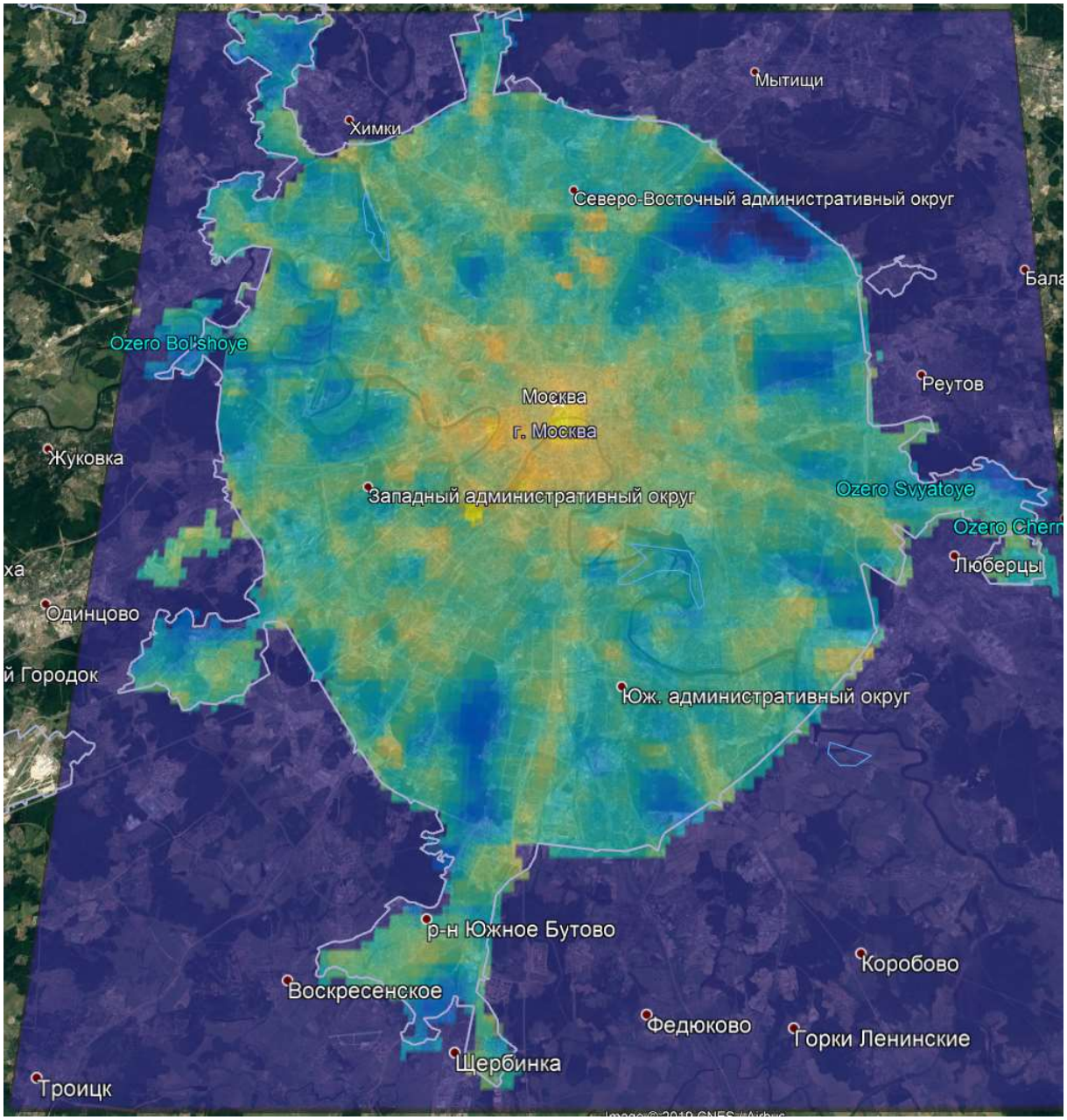
- ABSTRACT
  The distribution of brightness of nighttime lights (NTL) at the Earth's surface in the visible band of the electromagnetic spectrum is a new forward-looking data source for socio-economic studies. Visual and statistical analysis of this distribution in time and space requires new mathematical and geo-informational methods of cooperative processing of many raster images and vector data (geographical maps) together with socio-economic analytics. The current research develops new means of the spatiotemporal analysis, reveals basic problems of applied monitoring, and outlines forward-looking approaches to their solution.

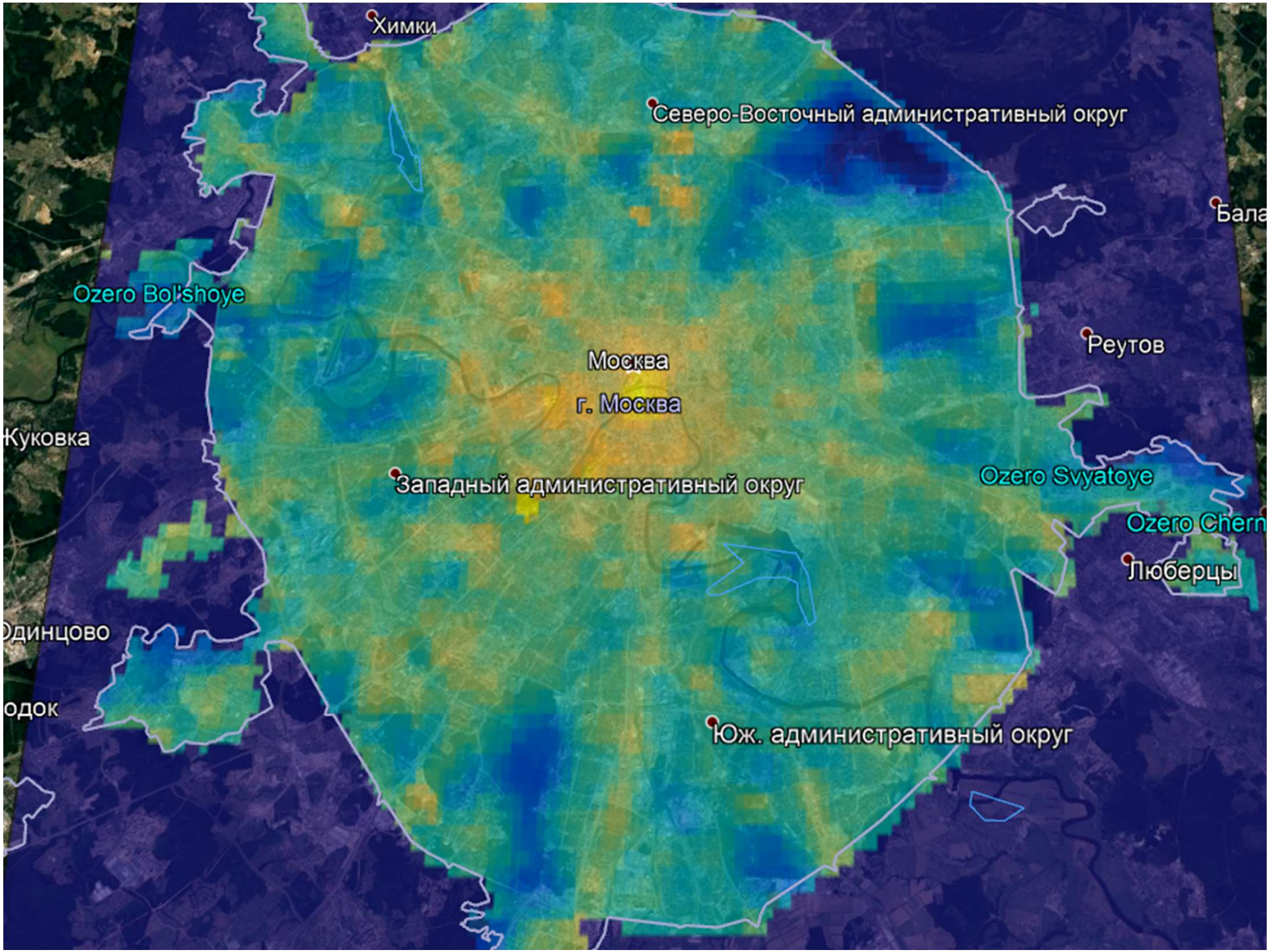
- KEYWORDS
  Remote Sensing, Night-time lights, data mining, big data, spatio-temporal analysis, socio-economic applications.

SPATIOTEMPORAL STATISTICAL ANALYSIS OF PATTERNS OF NIGHT-TIME LIGHTS (NTL) DYNAMICS DATA

An example of a brightness distribution

- Figure 1 demonstrates an example of a brightness distribution map of Moscow in the DNB channel. Yellow color corresponds to pixels with higher brightness, blue – to pixels with lower brightness. In order to create the map, the data were compressed with the use of a logarithmic function for the purpose of multiplexing the range of accepted data. The obtained image was laid over a map in the Google Earth application. The map contains several distinct large objects: the Kremlin and city center are much brighter even after a logarithmic compression; blue color corresponds to large forest park; major highways are clearly visible.

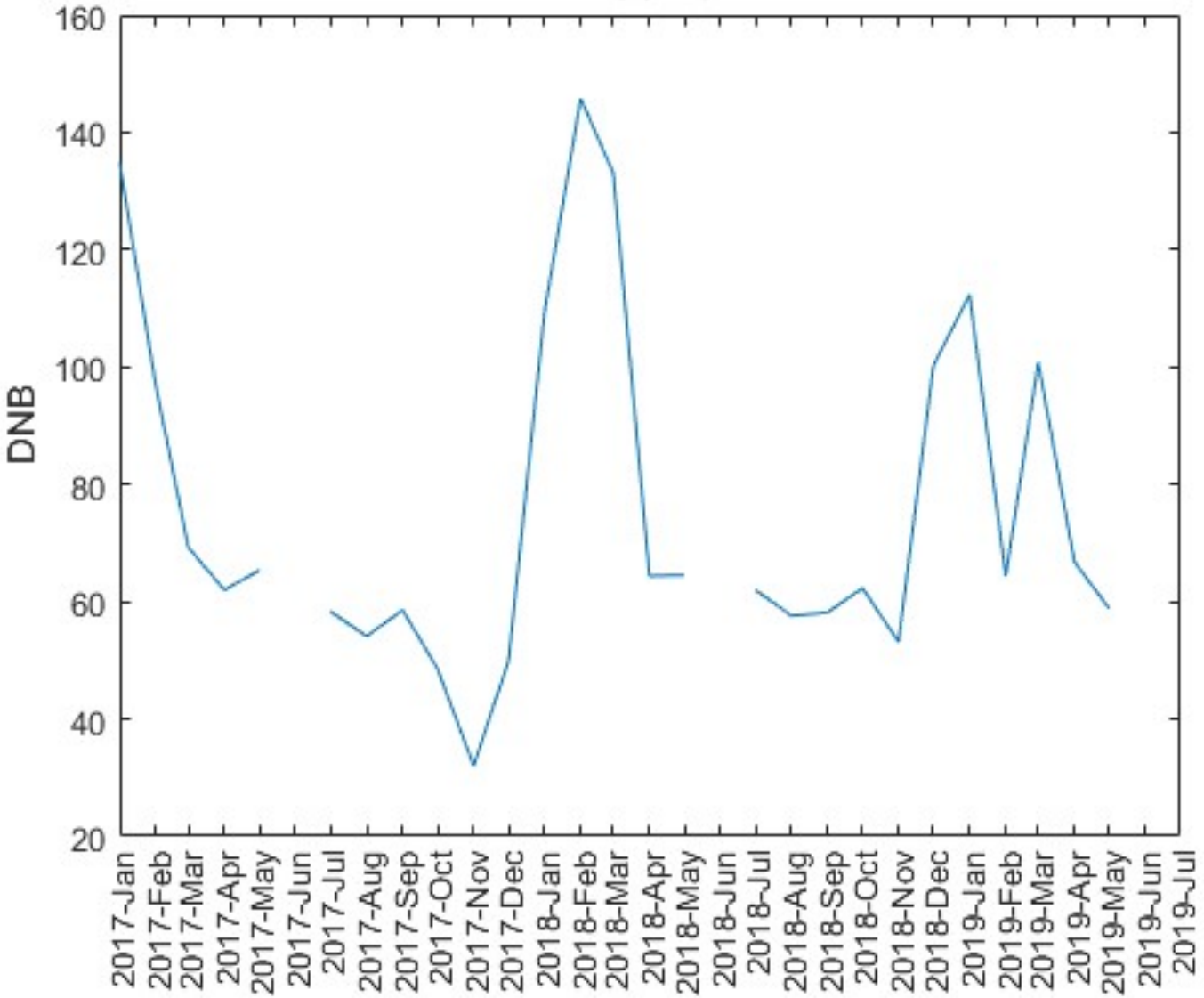



Химки
Северо-Восточный административный округ
Ozero Bol'shoye
Москва
г. Москва
Реутов
Куковка
Западный административный округ
Ozero Svyatoye
Люберцы
Южн. административный округ

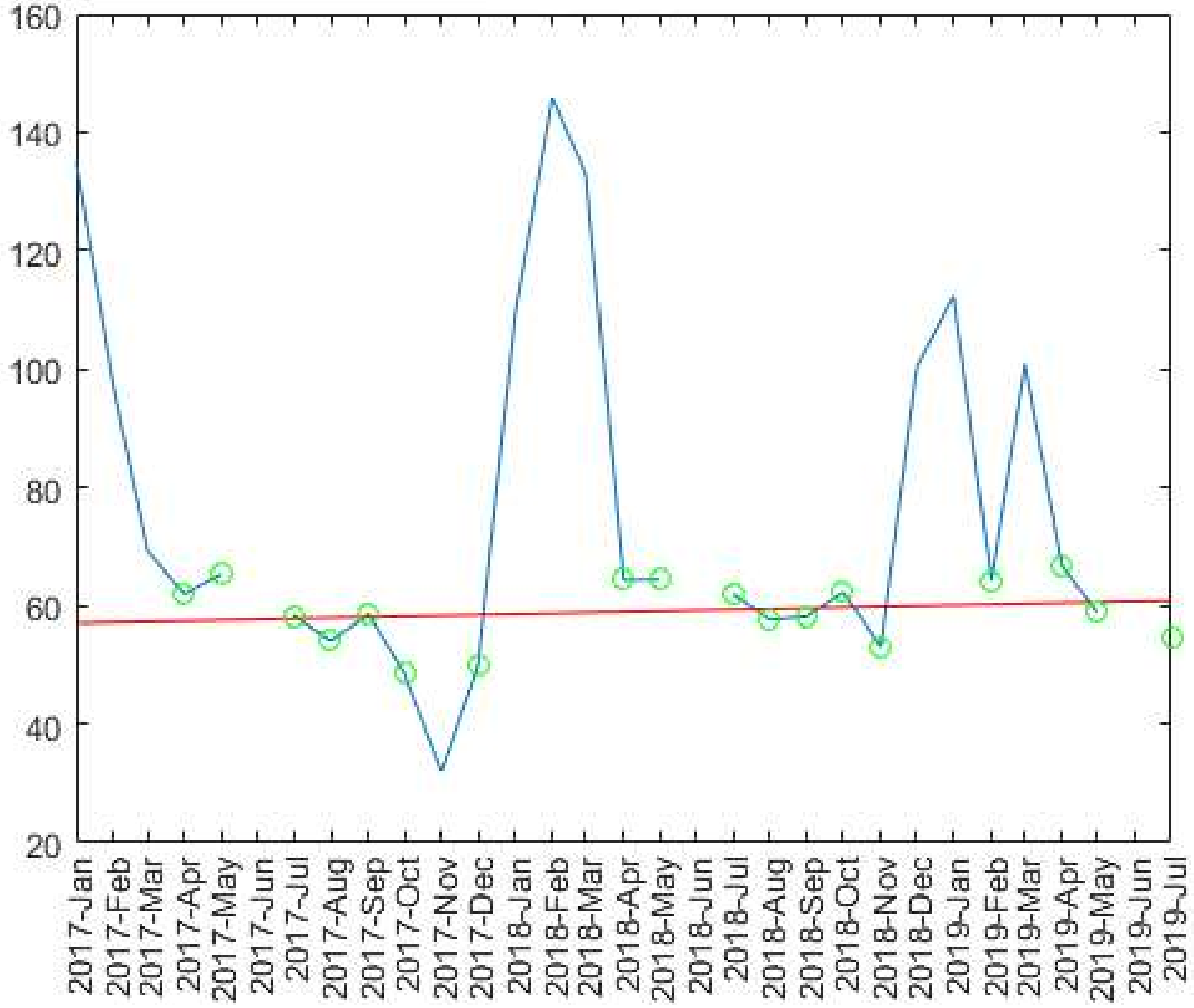
Abnormal indications

This figure demonstrates an example of a time sequence of the mean brightness value of pixels obtained in Moscow, that was formed starting from January 2017 till July 2019.

The graph is characterized by the absence of indications in several summer months and an abnormal increase in brightness during winter months.



Automatic exclusion of abnormal indications (using the RANSAC based algorithm)



APPLICATIONS OF THE PATTERN RECOGNITION METHOD IN TERMS OF TIME SEQUENCES OF NIGHT-TIME LIGHTS (NTL) BRIGHTNESS

Application to the estimation of Gross domestic product (GDP)

- German researchers Julia Bluszcz and Marica Valente in their recent work «The War in Europe: Economic Costs of the Ukrainian Conflict» used the “potential opportunities” approach for estimating the influence of the military conflict in Ukraine on the national GDP. In their work, the researchers evaluate the influence of the military conflict on the national GDP by defining the difference in prewar and postwar GDP rates that are extrapolated to postwar years.
- The authors estimate that, due to the Donbass war, Donetsk’s and Luhansk’s average GRP for 2013-2016 decreased by 43% (4630$) and 52% (3326$), respectively.
- For the period from 2012 to 2018 there is a consistent negative trend in the brightness of urban radiance in the entire territory of military conflicts in the so-called 'Donetsk People's Republic' and 'Luhansk People's Republic’. Using NTL data and non-parametric analysis of trends, we made our estimation of the GDP loss in these two regions.
- Our results perfectly correspond to the results obtained by Bluszcz& Valente (2019).

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- Bluszcz& Valente (2019) – econometric models

Donetsk:	Decrease in GDP	43%
Luhansk:	Decrease in GDP	52%

- RANEPA team (2020) – analysis of Night-time lights (NTL) trends

Donetsk:	Decrease in GDP	40%	(Δ = –3%);
Luhansk:	Decrease in GDP	53%	(Δ = +1%).

Our results perfectly correspond to the results obtained by Bluszcz& Valente (2019).

- Bluszcz& Valente (2019) – econometric models

  Donetsk: Decrease in GDP 43%
  Luhansk: Decrease in GDP 52%

- RANEPA team (2020) – analysis of nighttime lights (NTL) trends

  Donetsk: Decrease in GDP 40% (Δ = +3%).
  Luhansk: Decrease in GDP 53% (Δ = +1%).

STATISTICS

PHYSICAL SENSOR

Data are coherently and logically defined
Are registered by the same devise
Have global character
and the results from different regions can be compared

CONCLUSIONS

CONCLUSION

- The current research presents new methods of visualization of changes in NTL brightness at the Earth's surface underpinned by economic, sociologic, and political factors. A quantitative analysis of time sequences of the integral NTL brightness over a limited area in Russia is aggravated by interseasonal changes in albedo because of snow. The current research provides a new method of distinguishing interseasonal abnormalities on the basis of the RANSAC algorithm. After the separation of abnormalities in NTL brightness associated with climate characteristics, it is possible to apply pattern recognition for time sequences in the form of stepwise changes and trends associated with different socio-economic and political phenomena. This research presents the results of such analysis for Eastern Ukrainian cities affected by the military conflict since spring 2014.

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Thank you!