MULTIFACETED NATURE OF THE PHENOMENON OF LIGHT POLLUTION

Instytut
Innowacji i Technologii
Politechniki Białostockiej Sp. z o.o.

Prof. Tomasz Popławski
Czestochowa University of Technology
Faculty of Electrical Engineering
Department of Power Engineering

Dr hab. inż. Maciej Zajkowski, prof. PB
Bialystok University of Technology
Faculty of Electrical Engineering
Department of Photonics, Electronics and Light Technology

RESEARCH TOPIC

The use of artificial intelligence tools and machine learning methods to analyze and process satellite images and photos obtained from drones adapted to multispectral luminance measurements in order to detect and eliminate the adverse effect of light pollution.

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC

- Light pollution is one of the least researched and least mentioned environmental pollutants. Natural light is an essential element for the existence of life on earth. However, in some cases, light can be a significant problem.
- Light pollution is particularly affected by the improper use of artificial outdoor lighting, which has a negative impact on the environment.
- Wasted light, from artificial sources, emitted upwards (horizontal and higher), is scattered by aerosols, such as clouds, fog or fine particulate substances polluting the atmosphere. This scattering creates a glow in the night sky (light smog) that can be seen from a very long distance.

LIGHT POLLUTION IN EUROPE

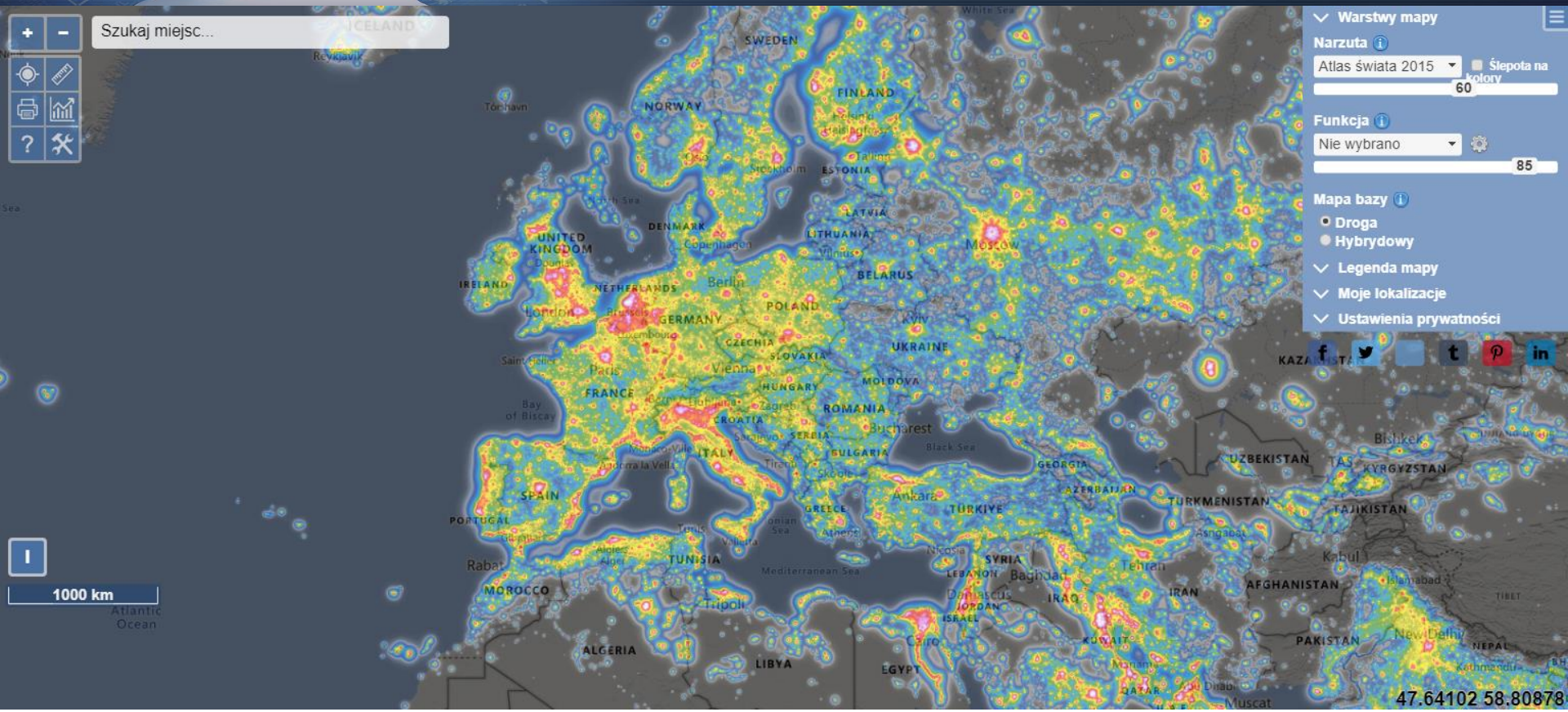


Fig.1. Light pollution in Europe.

Source: https://www.lightpollutionmap.info

LIGHT POLLUTION IN EUROPE

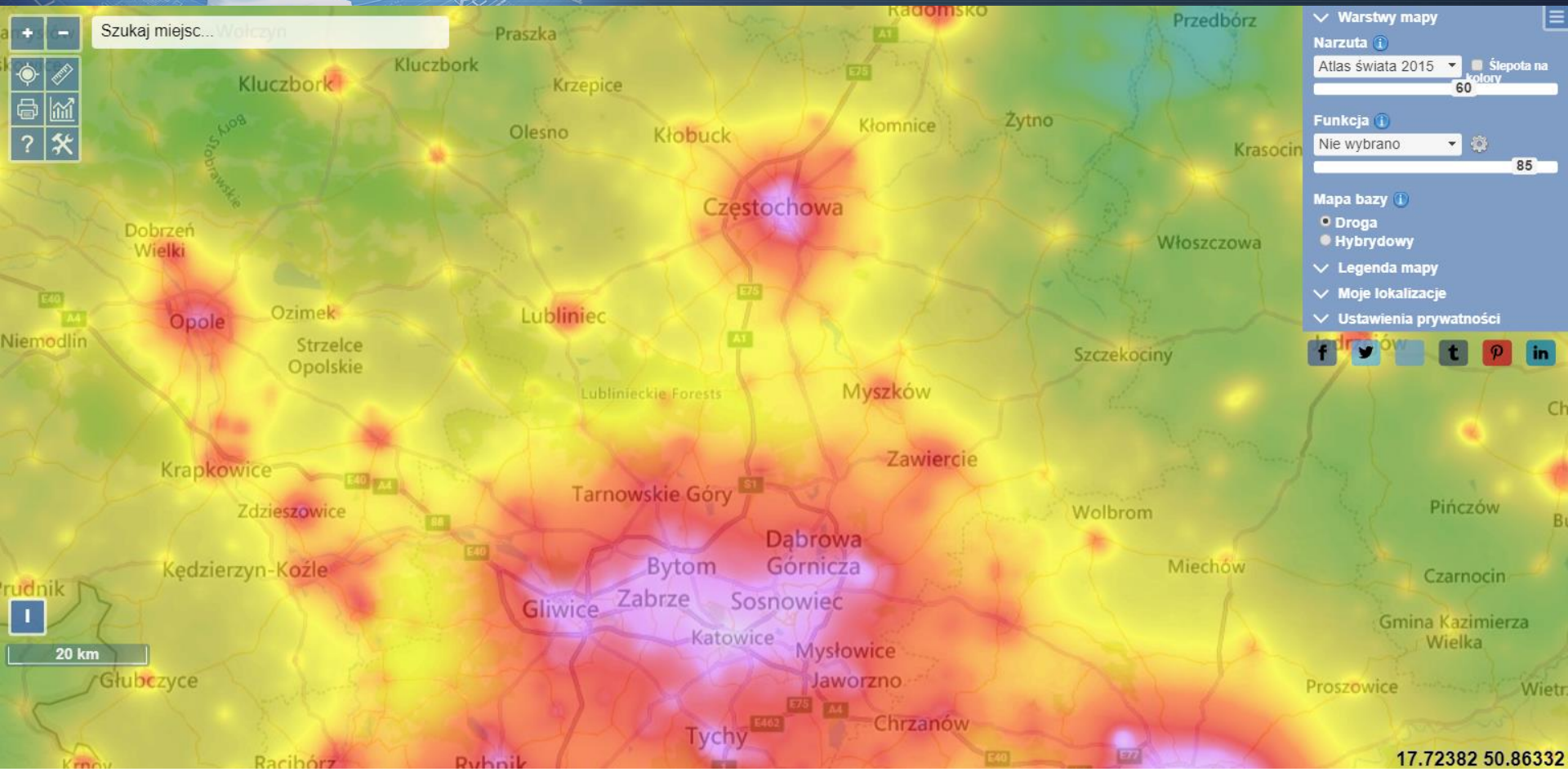


Fig.2. Light pollution in a highly urbanized area in Poland.

Source: https://www.lightpollutionmap.info

LIGHT POLLUTION IN EUROPE

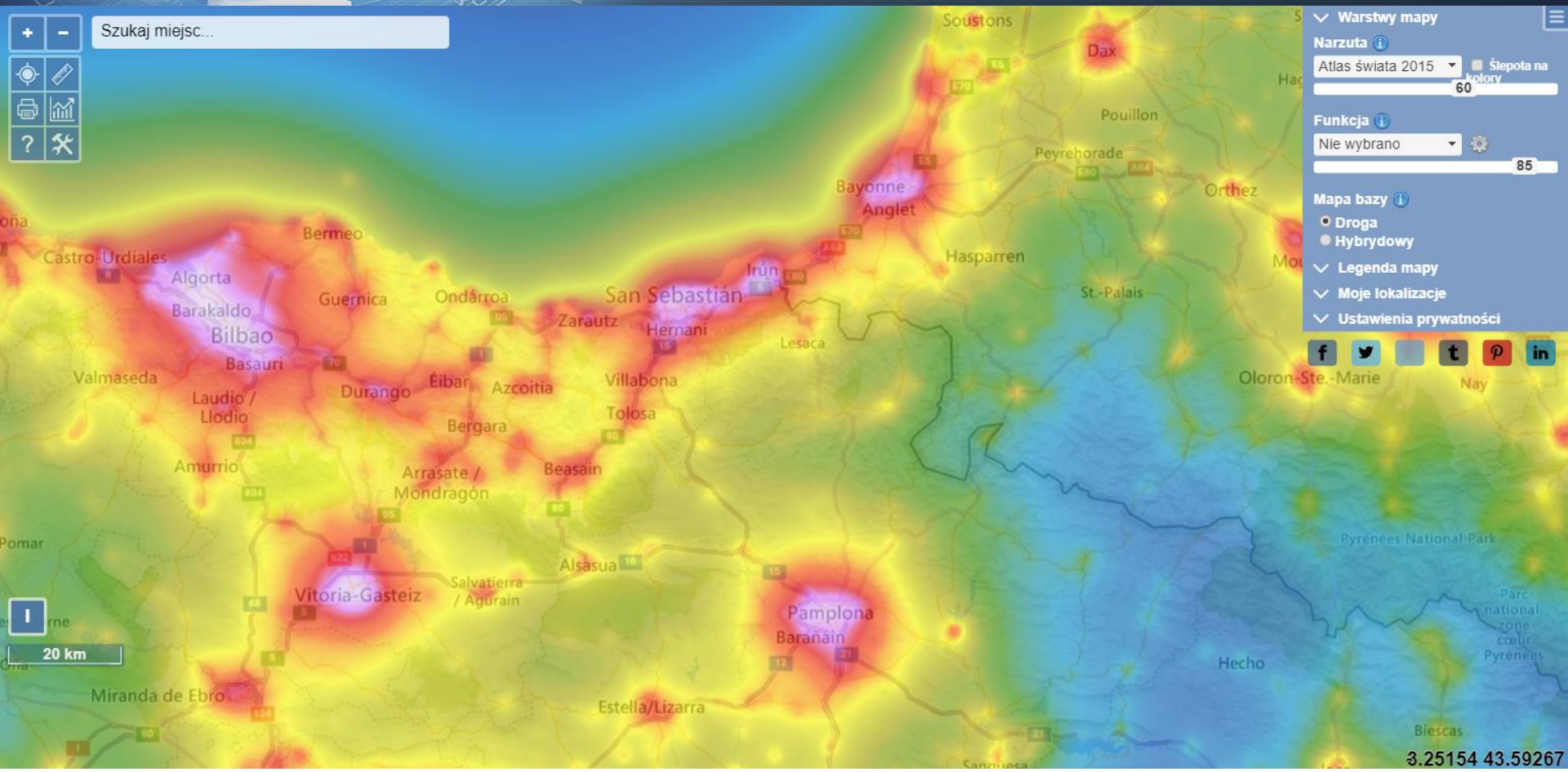


Fig.3. Light pollution in a highly urbanized area in Spain.

Source: https://www.lightpollutionmap.info

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC

- Street lighting in Poland, according to various estimates [1,2], consumes from 1500 to 2500 GWh of electricity and is responsible for a significant part of greenhouse gas emissions.
- Based on estimates, it is estimated that approx. 3.3 million street and road luminaires are used in Poland.
- Sodium and mercury sources dominate in lighting installations, accounting for up to 60% of emitters used. These sources are characterized by relatively low efficiency (about 40%), and the average age of such lighting installations is 15-30 years.

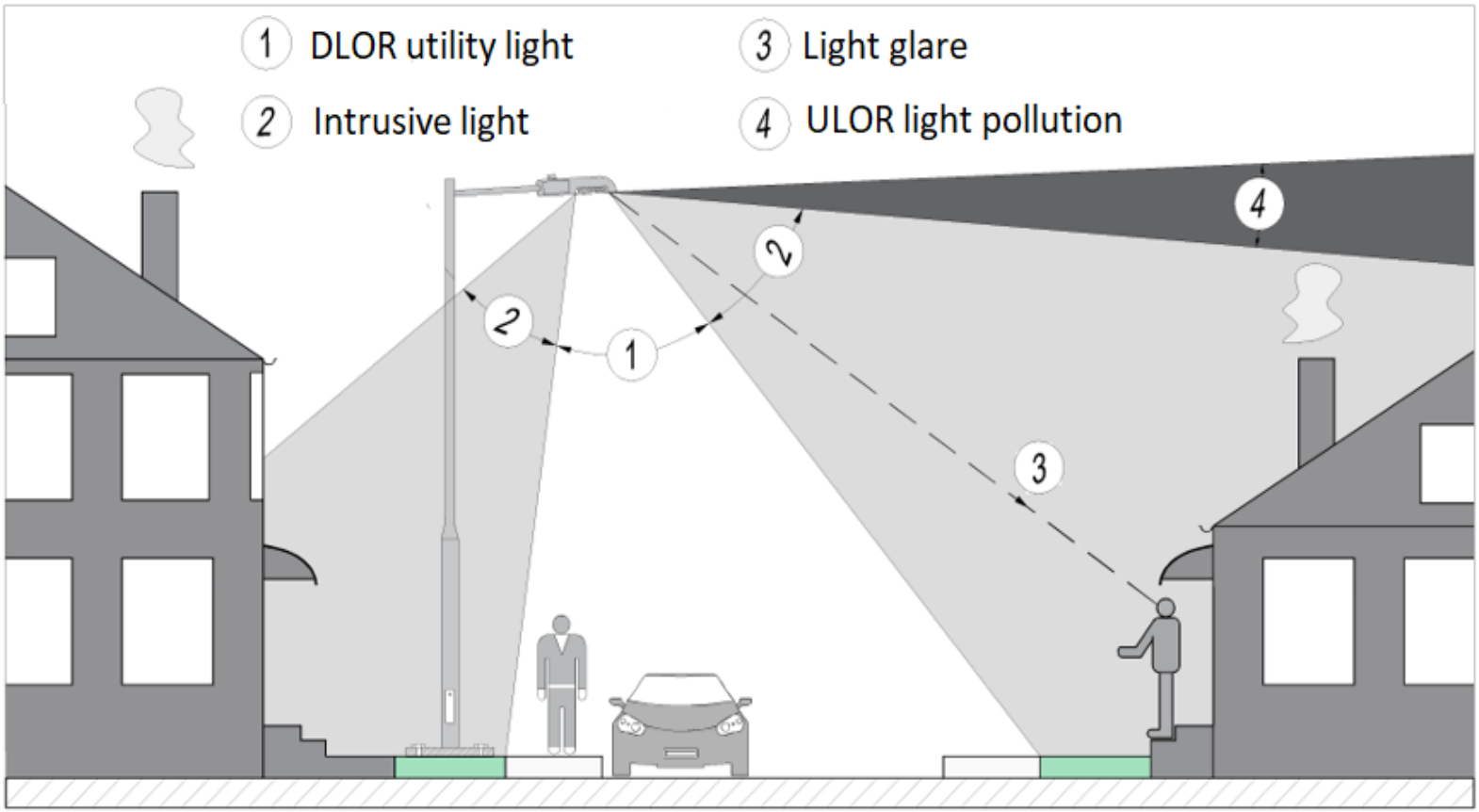
[1] Pracki P., Jägerbrand A., Application of road lighting energy efficiency evaluation system in practice. *Proceedings of the CIE Centenary Conference: Towards a New Century of Light, CIE*, Paris, (2013).

[2] Zajkowski M., The SOWA program for the modernization of road lighting in the commune, *Przegląd Elektrotechniczny*, R. 91 NR 7, (2015), s. 85 – 88.

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC

- In Poland, the energy consumption of street lighting is approximately 1.5% of the total electricity consumed in the country. However, in some cities, such as Warsaw or Krakow, the energy consumption of street lighting can be up to 40% of the total electricity consumed by the city.
- Light pollution is often the result of an improperly designed or constructed outdoor lighting network. It also results from the imperfection of the applied lighting technique.

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC



DLOR (Downward Light Output Ratio)
ULOR (Upward Light Output Ratio)

Fig.4. Light distribution from road luminaire.

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC

- *Quoting [3] in 2009, the American Medical Association (AMA) adopted a resolution stating that:*

"Spurious light has been implicated as a disruptor of human and animal circadian rhythms and as a significant medical cause of decreased melatonin production, suppressed immune system, and increased incidence of cancer such as breast cancer."

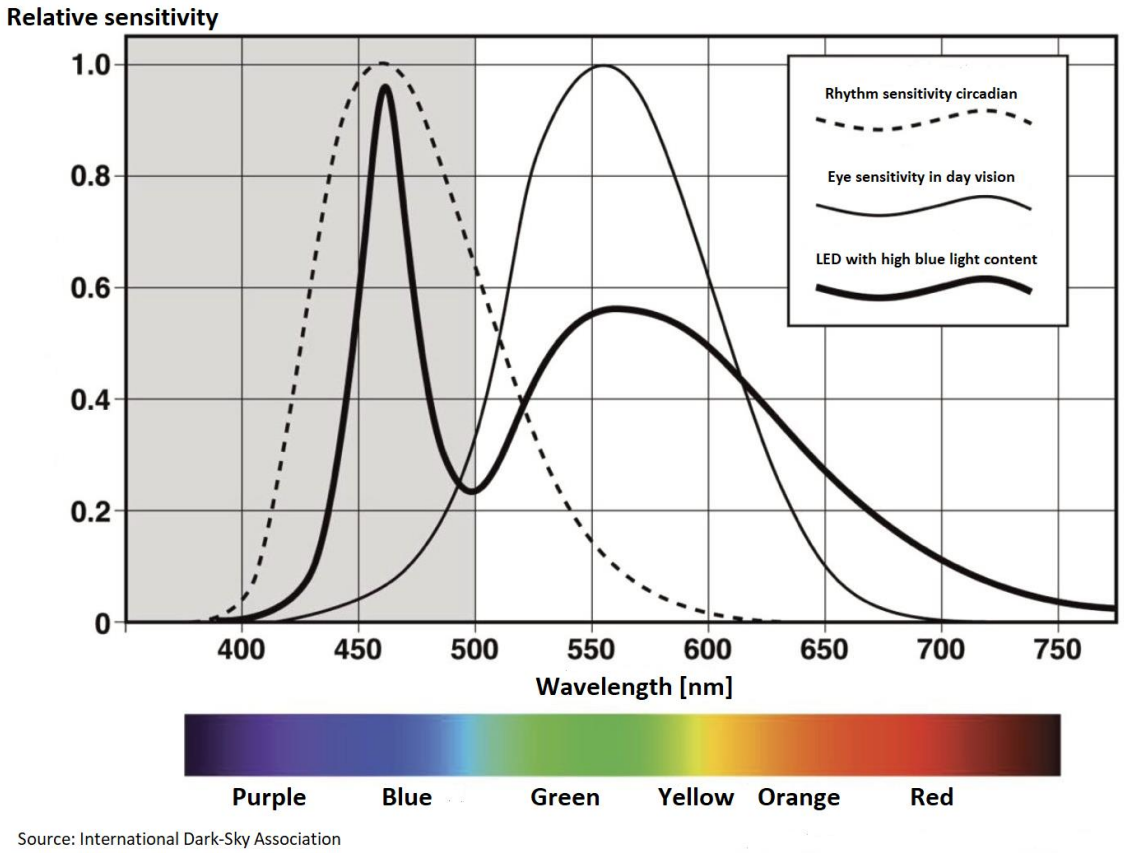
[3] Light pollution, Publication issued by the Polish Astronomical Society. The printing was co-financed by the Ministry of Science and Higher Education as part of the IAU100 project. 779/P-DUN/2019

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC

- In 2016, the AMA issued an official statement on LED lighting, explaining that **"LED lamps emitting white light have five times the impact on circadian sleep rhythms than conventional street lamps"**.
- According to [3], LED lamps have not only failed to combat light pollution, they are actually making matters worse. Research conducted by the group of Christopher C.M. Kyba'e, using satellite data, showed that between 2012 and 2016 there was a 9.1% increase in the brightness of our world.
- However, LEDs pose other serious problems due to the high content of blue light in their radiation spectrum. This light is scattered more strongly, affecting our ecosystems and public health.

[3] Light pollution, Publication issued by the Polish Astronomical Society. The printing was co-financed by the Ministry of Science and Higher Education as part of the IAU100 project. 779/P-DUN/2019

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC



Source: International Dark-Sky Association

Fig.4. Emissivity of white LED lamps against the background of the circadian rhythm and the sensitivity of the human eye.

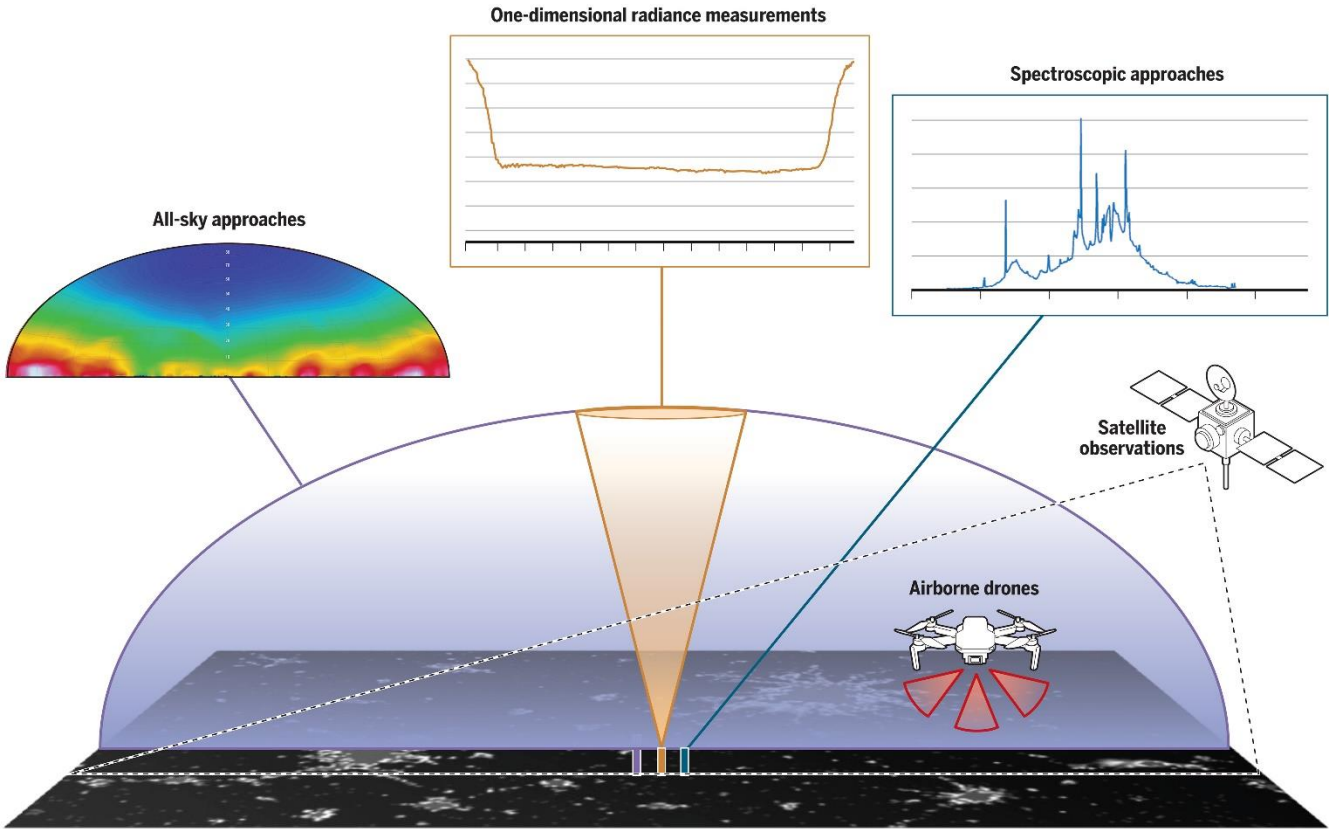
Source: https://www.lightpollutionmap.info

JUSTIFICATION OF THE UNDERTAKEN RESEARCH TOPIC

- Researchers and conservationists from the University of Newcastle, the UK Center for Ecology and Hydrology (UKCEH) and the UK charity Butterfly Conservation conducted a three-year study on the development of moth caterpillar populations along roadsides in the Thames Valley near well-lit and darkened areas. As a result, it turns out that LED lights turned out to be more harmful to insect populations than traditional sodium lamps. They show that in areas illuminated with LEDs, the number of night caterpillars and moths is 51% lower. Lower than in shaded areas. In places where there are still sodium lamps, populations are reduced by 41% [4].

[3] Source: https://www.focus.pl/artykul/pamietacie-jeszcze-dziure-ozonowa-z-konca-xx-wieku-naukowcy-sprawdzili-jak-wygladalaby-atmosfera-bez-ozonu

RESEARCH TOPIC CHALLENGE



Measuring and monitoring light pollution: Current approaches and challenges
MIROSLAV KOCIFAJ HTTPS://ORCID.ORG/0000-0001-9277-4692 , STEFAN WALLNER HTTPS://ORCID.ORG/0000-0001-5976-6965, ***SCIENCE,*** 15 Jun 2023, Vol 380, Issue 6650 ,p. 1121-1124, DOI: 10.1126/science.adg0473

PROPOSED RESEARCH TASKS

Task 1
Identification of light pollution issues in agglomerations and in rural and environmentally valuable areas
Task 2
Identification of basic outdoor lighting solutions affecting light pollution
Task 3
Measures of light pollution in the quantitative (sky luminance level) and qualitative (spectral distribution of sky radiation) aspects
Task 4
Methodology for calculating and measuring the luminous flux emitted towards the sky, with multispectral detection from space and from the surface of the earth (level above the location of light points - on average above 10m above the ground)
Task 5
Evaluation of the impact of air aerosols and clouds as well as the albedo and roughness of the ground on the way the light flux is dispersed

PRACE BADAWCZE I OPRACOWANIE MODELI DO BADAŃ LABORATORYJNYCH

Task 6
Prediction of the location, orientation, thickness of clouds and fluctuations in the spatial density of air aerosols in the context of planning energy demand for lighting purposes

Task 7
Development of a concept for a system for detecting multispectral luminance of the sky and distribution of the spectral flux reflected from the earth's surface

Task 8
Development of model drone systems for measuring the distribution of sky spectral luminance

Task 9
Development of a model layout of a high-resolution multispectral satellite detection system for assessing the distribution of luminance on the earth's surface

AGREGACJA DANYCH, BUDOWA TESTOWANIE I WERYFIKACJA ALGORYTMÓW OBLICZENIOWYCH

Task 10
Studies of the luminance distribution of selected agglomeration and rural areas as well as environmentally valuable areas using synchronized drone and satellite measurement systems, operating multispectral

Task 11
Aggregation and analysis of measurement data

Task 12
Development of model distributions of the sky luminance and the earth's surface corresponding to the selected distributions of climatic conditions, air quality and their condition, etc.

Task 13
Development of an algorithm for correcting the demand for electricity for outdoor lighting, with elements of prediction and machine learning

INITIAL PROPOSAL OF THE RESEARCH TEAM FROM POLAND

1. Prof. Tomasz Popławski
2. Dr hab. inż. Maciej Zajkowski, prof. PB
3. Dr hab. inż. Sebastian Dudzik, prof. PCz
4. Dr hab. inż. Grzegorz Dudek, prof. PCz
5. Dr inż. Marek Kurkowski
6. Dr inż. Piotr Szeląg
7. Dr inż. Urszula Błaszczak
8. Dr inż. Zbigniew Sołjan
9. Dr inż. Mateusz Prorok
10. Dr inż. Łukasz Gryko


Thank you
for your attention!