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SPATIO-TEMPORAL ANALYSIS OF ARTIFICIAL LIGHTING AT NIGHT BASED ON ANNUAL VIIRS DATA: A CASE STUDY OF BELGRADE AND PROKUPLJE

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ABSTRACT

Light pollution is one of the fastest-growing anthropogenic pollutants, with significant consequences for ecosystems, human health, and astronomical observations. Over the last few decades, satellites have successfully measured Artificial Light at Night (ALAN) and has quickly become one of the key tools for monitoring the spatial and temporal distribution of light pollution at various administrative levels. The most important source of data recently has been the Visible Infrared Imaging Radiometer Suite (VIIRS), which enables detailed analysis of global patterns and the temporal distribution of ALAN.

The aim of this paper is to analyze spatiotemporal changes in ALAN based on annual VIIRS composites, through a comparative study of two contrasting urban areas in the Republic of Serbia: Belgrade and Prokuplje. Belgrade is the capital city, highly urbanized and densely populated, which is why light pollution is the most prominent in this area. Within its administrative area lies a former astronomical observatory station where scientific observations were once conducted under a clear night sky, but are no longer possible. This makes it particularly interesting to assess the current level of light pollution at this location. Prokuplje is a city in southern Serbia with a diverse urban and rural landscape within its administrative boundaries.

In the darkest parts of the area lies the Astronomical Station “Vidojevica,” used for scientific research in Serbia and beyond. Both of these areas have specific terrain and urban morphology. The analysis of the spatial and temporal distribution of ALAN is conducted using annual VIIRS DNB composites available within the Google Earth Engine platform.

The methodological approach includes the delineation of the administrative boundaries of the analyzed cities, the extraction of satellite data over a defined period, and the calculation of basic statistical indicators (mean, median, maximum, and standard deviation of radiance). Additionally, spatial analysis has been conducted annually using thematic maps with the same classification to compare and map the spatial dynamics of ALAN expansion or reduction over time.

Results show more prominent and homogeneous patterns in highly urbanized areas of both cities, while less urbanized areas are more fragmented, with local hotspots where human activity is more intense. The temporal analysis shows moderate changes in total ALAN, mostly intensifying, with differences between the observed cities persisting throughout the analyzed period. However, the results obtained should be interpreted with regard to the limitations of satellite data. VIIRS sensors are less sensitive to the short-wavelength (blue) part of the spectrum, which can lead to underestimating ALAN intensity in areas with the latest LED technology. Also, yearly composites are aggregated values which do not reflect the seasonal variations and short-term changes in patterns of light pollution. Despite the limitations mentioned, this research's results confirm the importance of satellite data for monitoring long-term trends in light pollution and identifying spatial patterns of ALAN. The findings can have significant applications in planning sustainable lighting, protecting the dark sky, and developing policies to reduce the negative impacts of light pollution in urban and peri-urban environments.

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