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URBAN OBSERVATORY OF BELGRADE (UrbObsBel)

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Abstract. We present the 3-year project of the Urban Observatory of Belgrade, funded by the Science Fund of the Republic of Serbia, a new observing station within the Astronomical Observatory of Belgrade, Serbia. One of the main goals of the project is to measure and study one of the least understood forms of pollution on Earth, light pollution. We also plan to perform observations which will provide information on the distribution of energy consumption, which has a major impact on the environment and ecosystems. Our measurements will be made in Belgrade and also from the Vidojevica Astronomical Station near Prokuplje run by the Astronomical Observatory of Belgrade, one of the few remaining dark areas in Serbia. The results of the project are planned to be used by the Municipality of Zvezdara and the City of Belgrade because these measurements will provide elements for making decisions in the direction of creating a better environment that will improve the health of the population of Belgrade and its surroundings.

1. INTRODUCTION

The main goal of the 3-year UrbObsBel (Urban Observatory of Belgrade) project is further improvement and regional integration of the research capacity of the Astronomical Observatory of Belgrade (AOB) through construction of the new facility aimed at urban observations. These observations will provide valuable information on energy usage distribution that have a high impact on the environment and ecosystems. The study addresses an interesting cross-disciplinary topic that connects urbanization, ecology, industry and astronomy. This new infrastructure will be based on several observational instruments which will cover spectral range from visible ($\sim$ 400nm) to infrared ($\sim 13\mu$m). As one of the premier research institutions in the Western Balkans countries and the South Eastern Europe regions, the AOB is expected to play the key role in the processes of integration of the researchers gathered around space, astronomical, and astrophysical research into the wider European context, as envisioned in the European Research Area concept where the UrbObsBel project will be useful in that respect. The UrbObsBel project started in January 2024.

Figure 1: The project team: left to right, Dr. Dajana Bjelajac, Dr. Dragan Lukić, Dr. Zorica Cvetković, Dr. Srdjan Samurović, Dr. Rade Pavlović, Dr. Branislav Rovčanin and Dr. Zoran Simić. Missing Dr. Goran Damljanović.

2. PROJECT TEAM

The project team, see Figure 1, is well-equipped to successfully carry out all tasks of the UrbObsBel project. Each team member possesses the qualifications necessary to achieve the project's scientific objectives. The entire team will actively contribute to every phase of the project, including the design and construction of the Urban Observatory, data collection and analysis, and the dissemination of results. This collaborative approach ensures a comprehensive and cohesive effort toward achieving the project's goals.

The Principal Investigator, Dr. Srdjan Samurović, will manage the formal aspects of the UrbObsBel project, including procurement procedures, import logistics, and report writing, with support from the coordinators of other work packages (WPs). In addition, Dr. Samurović will handle the installation and maintenance of the project server, ensuring seamless operation. He will also supervise and collaborate across all WPs, actively participating in their activities to ensure alignment and smooth execution of project tasks.

Dr. Zorica Cvetković, coordinator of WP2, and Dr. Rade Pavlović, coordinator of WP3, bring extensive expertise in instrumentation and software, making them ideal for handling the technical aspects of the UrbObsBel project. Dr. Cvetković will oversee the specifications, procurement, installation, and mounting of the necessary hardware and instruments. Dr. Pavlović will manage software installation, maintenance, and data management processes. Additionally, both coordinators will oversee auxiliary observations at the Astronomical Station Vidojevica, operated by the Astronomical Observatory of Belgrade, to ensure seamless support for the projects observational needs.

Dr. Goran Damljanović, the leader of WP4, will apply his expertise to the acquisition and analysis of imagery for the UrbObsBel project.

Dr. Zoran Simić will focus on analyzing observational data and managing data integrity and organization.

Dr. Dragan Lukić has a strong background in experimental atomic, molecular, and optical physics, as well as experience in experimental astrophysics, making him a key contributor to the projects technical and analytical tasks.

Dr. Branislav Rovčanin will participate in observational activities, contribute to data analysis, and assess the impact of light pollution on public health using the data collected.

Dr. Dajana Bjelajac, the leader of WP5, will coordinate dissemination of the results and outreach, leveraging her expertise in light pollution to manage the use and operation of the detector suite acquired for the UrbObsBel project.

This multidisciplinary team brings together diverse expertise to advance the UrbObsBel projects goals effectively.

3. CONCEPT AND METHODOLOGY

The proliferation of artificial light at night (ALAN) has introduced a complex form of environmental disruption commonly referred to as light pollution (LP). With electric lighting becoming widespread in the 19th century, artificial light has increasingly impacted ecosystems and human health worldwide. Recent studies, such as the one by Sanchez de Miguel et al. (2022), which utilized data from cameras mounted on the International Space Station from 2012 to 2020, reveal the growing extent of ALAN across the globe.

Light pollution, a subset of environmental pollution, shares this category with other forms like air pollution, noise pollution, and water pollution, among others. LP has both natural and artificial sources, though the latter, generated by human activities, is rising at a troubling rate of 3–6% annually. Although light pollution may seem less immediately harmful compared to other types of pollution, its ecological and physiological impacts are substantial and far-reaching, affecting humans, plants, animals, and microorganisms alike.

Research has shown that nearly two-thirds of the worlds population lives in areas where nighttime light levels exceed natural thresholds. This level of exposure to artificial brightness disrupts not only natural ecosystems but also human health. For example, Falchi et al. (2016) highlighted the cultural and sensory deprivation caused by LP, showing that one-third of the global population cannot view the Milky Way due to excessive artificial lighting. This widespread impact on night-sky visibility underscores the need to understand and mitigate LPs growth and effects comprehensively.

LP poses a substantial threat beyond its impact on astronomy, as it disrupts ecosystems and leads to significant energy wastage. Urban areas, especially large cities, experience the highest levels of LP, making it critical to map LP sources and identify cases where mitigation efforts could be effective. Initiatives like those by the International Dark-Sky Association aim to create comprehensive global LP maps. This process often involves measuring the brightness of standard stars using Johnson filters and small telescopes equipped with CCD cameras. By determining extinction coefficients in starless areas, researchers can infer overall sky brightness, an approach that also engages the public through educational outreach.

While the study of LP has traditionally received limited attention, the development of specialized photometric instruments has sparked renewed interest among professional astronomers. For instance, Sky Quality Meters (SQMs) provide single-band measurements of night sky brightness (NSB) when pointed at the zenith, offering valuable data for assessing LP's impact on observational conditions. Additionally, digital single-lens reflex (DSLR) cameras equipped with fisheye lenses offer spatially resolved NSB data over a broad, 180-degree field of view and capture light in three spectral channels, giving a more comprehensive view of LP distribution.

In recent years, technological advancements have expanded the range of instruments used to study LP and its environmental effects. Broadband infrared devices and hyperspectral imagers, in particular, have become valuable tools for more detailed LP analysis. These innovations, along with the existing devices, form the foundation of our proposed Urban Observatory, which will enable a more systematic approach to monitoring LP and assessing its multifaceted impacts on both urban and natural environments.

LP problem is especially serious in urban environments. According to the United Nations, today, 55% of the worlds population lives in urban areas, and this proportion is expected to increase to 68% by 2050. Therefore, the need to address the problems of ALAN and LP is obvious.

Serbia has many light polluted areas but also the regions with a clear sky (see `https://www.lightpollutionmap.info`). One of the remaining dark spots is the Vidojevica mountain where Astronomical Station run by the Astronomical Observatory of Belgrade is situated. The participants of UrbObsBel played an important role in its construction. The SQM zenith sky brightness there is $\sim 21.69\quad \mathrm{mag/arcsec^2}$. We plan to mount some auxiliary instruments there. Belgrade, the capital of Serbia, with 1.7 million inhabitants, is the brightest spot in Serbia with the SQM zenith sky brightness of $\sim 17.73\quad \mathrm{mag/arcsec^2}$ in its downtown area.

You can see more about the purchased instruments, the data usage, and the first obtained result in this volume in our paper "The UrbObsBel Project: Instruments and Detectors" (Pavlovic et al., 2025).

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