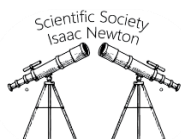


2nd International Meeting on Building Bridges Between Climate Science and Society Through a Transdisciplinary Network

21-25 September 2026, Belgrade, Serbia & virtual

BOOK OF ABSTRACTS AND CONTRIBUTED PAPERS

Edited by Milica Langović, Aleksandra Kolarski,
Vladimir A. Srećković, Marko Langović, Filip Krstić,
Ivana Đorđević



Belgrade, 2026

SCIENTIFIC COMMITTEE

Aleksandra Kolarski, Serbia
Aleksandra Nina, Serbia
Felix Iacob, Romania
Filip Krstić, Serbia
Gordana Jovanović, Montenegro
Hans Eichelberger, Austria
Luka Popović, Serbia
Magdalena Hristova, Bulgaria
Marija Ljakoska, North Macedonia
Marko Langović, Serbia
Milan Dimitrijević, Serbia
Milica Langović, Serbia
Nebil Ben Nessib, Saudi Arabia
Nicolina Pop, Romania
Nikola Veselinović, Serbia
Nikolay Bezuglov, Russia
Ognyan Kounchev, Bulgaria
Olgu Aydın, Türkiye
Rafik Hamdi, Tunisia
Slavoljub Dragičević, Serbia
Vladimir A. Srećković, Serbia
Zoran Mijić, Serbia
Zoran Vidović, Serbia

ORGANIZING COMMITTEE

Milica Langović, Serbia,
Nikola Veselinović, Serbia
Marko Langović, Serbia
Filip Krstić, Serbia
Ivana Đorđević, Serbia
Zoran Vidović, Serbia
Luka Đurović, Serbia

Organizers

Scientific Society Isaac Newton Belgrade
Institute of Physics Belgrade, University of Belgrade
Astronomical Observatory Belgrade

UNDER THE SUPPORT OF the Ministry of Science, Technological
Development and Innovation of the Republic of Serbia

Technical organizer: PanaComp Wonderland Travel, Novi Sad, Serbia

SCIENTIFIC RATIONALE

The linkage between climate and society highlights a profound reciprocity, where climate shapes the foundations of social structures, while societies themselves transform the climate. This conference aims to bring together researchers, practitioners, and professionals from diverse fields to address complex emerging challenges related to these issues. Participants will have the opportunity to explore innovative perspectives, share research findings, and discuss practical approaches for integrating knowledge across disciplines. By fostering dialogue and cooperation, the conference seeks to encourage new partnerships and advance interdisciplinary solutions.

Venue

Institute of Physics Belgrade, National Institute of the Republic of Serbia,
University of Belgrade, Serbia & virtual

Date: 21–25 September 2026

Conference type: International scientific conference

ISBN-978-86-906850-3-5

Published and copyright by: Scientific Society Isaac Newton Belgrade

Printed by: Skripta Internacional, Mike Alasa 54, 11102, Beograd

Number of copies: 50

Editors:

Milica Langović, Institute of Physics Belgrade, University of Belgrade, Serbia

Aleksandra Kolarski, Institute of Physics Belgrade, University of Belgrade, Serbia

Vladimir A. Srećković, Institute of Physics Belgrade, University of Belgrade, Serbia

Marko Langović, Faculty of Geography, University of Belgrade, Serbia

Filip Krstić, Faculty of Geography, University of Belgrade, Serbia

Ivana Đorđević, Faculty of Geography, University of Belgrade, Serbia

Reviewers:

Aleksandra Nina

Institute of Physics Belgrade, University of Belgrade, Serbia

Marija Ljakoska

Saints Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institute of Geography, Skopje, North Macedonia

Slavoljub Dragićević

Faculty of Geography, University of Belgrade, Serbia

Zoran Mijić

Institute of Physics Belgrade, University of Belgrade, Serbia

Mihailo Savić

Institute of Physics Belgrade, University of Belgrade, Serbia

Zoran Vidović

Faculty of Education, University of Belgrade, Serbia

Aleksandar Petrović

Faculty of Geography, University of Belgrade, Serbia

CONTENTS

Plenary Invited Lectures

Milan S. Dimitrijević, Vladimir A. Srećković, Veljko Vujčić <i>Molecular data for climate science</i>	12
Aleksandar Valjarević <i>Linking Climate Stress, Land-Use Change and River-System Sustainability: A GIS-Based Ecological Equilibrium Index for Serbia</i>	14

Invited Lectures

Filip Naumovski, Marija Ljakoska, Emilija Manevska, Arse Kuzmanoski, Anita Todorova <i>Perceptions and Attitudes Toward Temperature Trends and Climate Change in North Macedonia: A Survey-Based Analysis</i>	21
Lamia Abu El Maati, Nabil Ben Nessib, Milan S. Dimitrijević <i>On the atomic structure of the seven-times ionized sulfur ion S VIII</i>	23
Dejan Vasović, Ana Stojanović, Sladjan Hristov <i>Tracing the Path from Soil Erosion to Drinking Water Risk: A Modelling Framework for Water Safety Planning</i>	24
Igor Leščesen <i>Hydrological Droughts in the Carpathian Basin: From Historical Evidence to Future Risk under CMIP6 Climate Scenarios</i>	31
Jelena Svetozarević <i>Continentalty Indices as a Common Language for Climate and Society: A Precipitation Seasonality - Case Study Babušnica (Serbia) - Sofia (Bulgaria) 1961-2020</i>	37

Lectures

Natalija Nikolić, Milica Vasić <i>Heat Waves in Rural Regions of Serbia: Who is the Most Vulnerable?</i>	40
Tijana Radosavljević, Sanja Manojlović <i>Trend of air temperature at the meteorological station Vranje during the period 1949-2024</i>	42

Zoran Mijić, Bratislav Marinković	51
<i>Review of the COST networking activities - modifications of the rules and introduction of new opportunities for ITC participants</i>	
Milica Langović, Zoran Vidović	53
<i>Air Pollution as a Driver of Population Mobility: Empirical Evidence and Underlying Mechanisms</i>	
Aleksandra Nina, Pier Francesco Biagi, Giovanni Nico, Hans U. Eichelberger, Mohammed Y. Boudjada	55
<i>VLF amplitude noise reductions as earthquake precursors: statistical analysis</i>	
Filip Krstić, Mirjana Gajić	58
<i>Climate Aridity Changes and Their Impact on Agricultural Production - Case Study: South Serbia</i>	
Ivana Đorđević, Mina Marković, Slavoljub Jovanović	65
<i>Is climate sufficiently present in the classroom? An analysis of content and outcomes on climate change in Geography curricula in primary schools</i>	
Veljko Vujčić	73
<i>Semantic Orchestration for Time-Domain Astronomy</i>	
 <i>Posters</i>	
Zoran Vidović	75
<i>Statistical Methods for Analysing Environmentally Induced Migration Intentions</i>	
Emilija Manevska, Arse Kuzmanoski, Filip Naumovski, Anita Todorova, Marija Ljakoska	76
<i>Correlation between air temperature and air pollution in the city of Skopje</i>	
Peter Bednár, Aleksandra Nina, Aleksandra Kolarski, Peter Butka, Martin Sarnovský, Vladimir Srećković, Ognyan Kounchev	78
<i>Ionospheric Disturbances & Machine Learning: VLF Signal Variation Detection and Perspectives</i>	

Milica Langović, Vladimir A. Srećković, Georgi Boyadjiev, Ognyan Kounchev, Hans U. Eichelberger, Georgi Simeonov <i>The Astro-Geo Interface: Prospects and Directions for Future Research</i>	80
Marko Langović, Nenad Živković, Slavoljub Dragičević <i>Assessment of Long-Term River Discharge Variability and Precipitation Coherence: The South Morava River, Serbia</i>	82
Luka Đurović <i>Spatial Distribution of Floods and Earthquakes in Southern Europe: An Analysis at the NUTS 3 Regional Level (1990–2025)</i>	88
Vladimir Srećković, Georgi Boyadjiev, Ognyan Kounchev, Aleksandra Kolarski, Milica Langović, Aleksandra Nina, Zoran Mijić, Hans U. Eichelberger <i>Big Data Analysis in Astrophysics and Physics: A Multidisciplinary Approach</i>	90
Nikola Veselinović, Mihailo Savić, Darije Maričić, Mila Ranitović, Dejan Joković, Radomir Banjanac, Žarko Medić <i>Recent Solar Activity: A Preliminary Analysis Based on Cosmic-Ray Observations</i>	92
Marko Langović <i>Process-based insights into lateral channel migration and riverbank erosion under climate variability</i>	93
Radoslav Ranković, Slađana Popović <i>Changes in Temperature and Precipitation Regimes in the Šumadija Region, 1961–2024</i>	95
Vladimir A. Srećković, Nicolina Pop, Veljko Vujčić, Magdalena D. Christova, Felix Iacob, Milica Langović, Aleksandra Kolarski <i>New dataset for planet formation chemistry and modeling</i>	102
Ana Nešić, Katarina Damjanović, Sara Tadić, Teodora Jovičić, Aleksa Muljajić <i>Perceptions of Air Pollution in Belgrade: A Survey Analysis</i>	104
Stefan Manojlović <i>Discharge Trend Dynamics of the Nišava River (Serbia)</i>	111

Vladimir A. Srećković, Violeta Petrović, Hristina Delibašić Marković <i>New Molecular Datasets for Modeling Astrophysically Relevant Radiative Processes</i>	118
Luka Đurović <i>Earthquakes and Population Vulnerability: Evidence from Southern Europe</i>	120
PROGRAM SCHEDULE	121
CONFERENCE PROGRAM	122
AUTHORS' INDEX	128

Plenary Invited Lectures

[<https://doi.org/10.69646/aob260901>]

[Plenary Lecture]

Molecular data for climate science

Milan S. Dimitrijević¹, Vladimir A. Srećković², Veljko Vujčić¹

¹Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia

²Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

*Correspondence: mdimitrijevic@aob.rs

Abstract: For investigation and understanding of atmospheric processes influencing on climate and for research of chemical reactions and processes in atmosphere, reliable molecular data may be of great interest. However, the main problems which are an obstacle for an efficacious search and use of the needed molecular data are among others: a) Lack of standards; b) Interoperability; c) Data exchange; d) Critical evaluation. In order to solve these problems on July 1 2009 Virtual Atomic and Molecular Data Center (VAMDC – Albert et al., 2020, Dubernet et al., 2010, 2016) started, first as a FP7 project: Now it is a Consortium of Databases and Services Providers that has built a unified, secure, documented, flexible and interoperable e-science environment-based interface e-Infrastructure for the exchange of atomic and molecular data. It connects 39 databases which can be searched simultaneously and its partners are from Australia, Austria, France, Germany, India, Italy, Japan, Korea, Russia, Serbia, South Africa, Sweden, UK, USA and Venezuela. The databases contain many different molecular data of interest as for example kinetic data interesting for astrochemical (planetary atmospheres and interstellar medium) studies, photo dissociation cross-sections of molecular ions from individual rho-vibrational states and cross-sections and rate coefficients for radiative ion-atom collisional processes, collisional rho-vibrational excitation of molecules by colliders such as atom, ion, molecule or electron, catalog of radio frequency and microwave to far-infrared spectral

lines of atomic and molecular species that (may) occur, for example, in planetary atmospheres, bibliographic database of literature on fundamental atomic and molecular processes etc. In this contribution we will present Virtual Atomic and Molecular Data Center and the corresponding molecular databases of interest for atmospheric research.

Keywords: Molecular data, Databases, e-infrastructure, Data exchange

References

- Albert, D.,... Dimitrijević, M. S., ... Srećković, Vladimir A., ... Vujčić, Veljko et al. (2020) *Atoms*, 8, 76.
- Dubernet, M. L., Boudon, V., Culhane, J. , Dimitrijević, M. S. et al. (2010) *JQSRT*, 111, pp. 2151-2159.
- Dubernet, M. L., ... Dimitrijević, M. S., ... Vujčić, V. et al. (2016) *J. Phys. B*, 49, 074003

[<https://doi.org/10.69646/aob260902>]

[*Plenary lecture*]

Linking Climate Stress, Land-Use Change and River-System Sustainability: A GIS-Based Ecological Equilibrium Index for Serbia

Aleksandar Valjarević^{1*}

¹Faculty of Geography, University of Belgrade, Department of Geospatial and Environmental Science, Studentski Trg 3/III, 11000 Belgrade, Serbia

*Correspondence: aleksandar.valjarevic@gef.bg.ac.rs

Abstract: River systems are increasingly exposed to interacting pressures from land-use change, urbanization and climate extremes. This study presents a GIS-based Ecological Equilibrium Index (EEI) for national-scale screening of river-system sustainability in Serbia. The operational index integrates land-use/land-cover ecological support, normalized river-network density and land-use pressure on a harmonized 100 × 100 m grid, while climate, demographic and water-related hazards are used as supporting layers for interpretation. The national mean EEI is 0.149, indicating a slightly positive but transitional condition, with low and very low values concentrated along major urban-industrial river corridors. River-network reductions of 20% in Belgrade, 18% in Novi Sad, 15% in Niš and 13% in Pančevo coincide with intensified land transformation. Climate stress can further amplify these pressures through drought, reduced dilution, intense runoff and flood hazards, highlighting the need for integrated spatial planning, river restoration and climate adaptation.

Keywords: climate change; ecological equilibrium index; river systems; land-use change; GIS

Introduction

River systems are among the most sensitive interfaces between climate, land use and society. Changes in temperature and

precipitation regimes alter runoff, low-flow conditions, flood frequency, erosion and pollutant transport, while urban expansion, agricultural intensification and infrastructure development modify drainage connectivity, riparian zones and floodplains. These processes rarely act independently. Climate stress can magnify the effects of land transformation, particularly where water demand, wastewater generation and impervious surfaces are concentrated along major river corridors (Fussmann et al., 2014; Zhou, 2014). For this reason, river sustainability requires spatially explicit approaches able to connect ecological support, hydrological structure and anthropogenic pressure within a common analytical framework.

Serbia provides a suitable national-scale case because its major development axes overlap with the Danube, Sava, Tisza, Drina, Velika Morava and Nišava river systems, while southern and eastern regions are additionally exposed to drought, flood hazards, water scarcity and infrastructure limitations (Milovanović et al., 2022). The objective of this invited lecture is to demonstrate how a transparent GIS-based Ecological Equilibrium Index (EEI) can be used as a screening tool for river-system sustainability and how climate-related stress can be incorporated as an interpretative and planning layer without obscuring the operational structure of the index. The broader aim is to bridge geospatial environmental assessment with climate adaptation and practical water-management decisions.

Methods and data

The EEI was calculated on a harmonized 100 × 100 m raster grid in WGS 84 / UTM Zone 34N (EPSG:32634). ESA WorldCover at 10 m resolution provided the primary land-use/land-cover (LULC) information. SRTM elevation data, national hydrographic layers and historical topographic maps were used to derive and verify river-network structure, while Sentinel-2, Landsat and CORINE data supported interpretation of land-cover change. Population, settlement, urban-industrial, climate, hazard and water-quality datasets were used as independent supporting evidence rather than

as direct mathematical components of the simplified index. This separation keeps the EEI reproducible while allowing climate and societal pressures to be analysed alongside it (Valjarević, 2024; Chatrabhuj et al., 2024).

LULC classes were reclassified into ecological-support and pressure coefficients. River density was calculated using an approximately 5-km-radius circular moving window and normalized to a 0–1 range. The EEI equation presented in this study is an original formulation conceived and developed by Aleksandar Valjarević; it builds on his GIS-based research on river-network sustainability and ecological vulnerability (Valjarević, 2026a; Valjarević, 2026b). The operational formulation is:

$$EEI = [(LULC_{positive} + RD_{norm}) / 2] - LULC_{pressure}$$

where $LULC_{positive}$ represents ecological support from vegetation, wetlands and water-related land cover, RD_{norm} represents normalized local river-network density, and $LULC_{pressure}$ represents mapped pressure associated mainly with built-up and intensively transformed land. The theoretical EEI range is –1 to +1. Negative values indicate dominance of mapped pressure, values near zero indicate transitional balance, and positive values indicate stronger ecological support. Buffer zones of 0–2 km, 2–5 km and >5 km around major river and urban-industrial corridors were used to evaluate proximity effects. Historical changes between 2002 and 2022 and a 2050 trend-continuation scenario were used to assess emerging spatial pressure. Climate information was interpreted as a stress multiplier, particularly for drought, low-flow, intense runoff and flood-prone regions; GIS-based drought assessment provides a complementary framework for this interpretation (Penny et al., 2023).

Results and discussion

The national mean EEI was 0.149 (approximately 0.15), with values from –1.000 to approximately 0.56 and a standard deviation of 0.421. This indicates a slightly positive but vulnerable transitional condition at national scale, while also revealing strong spatial contrasts. High

EEL values were associated mainly with forest-dominated, wetland, water-related and less urbanized landscapes. Low and very low classes covered 31.364% of the valid classified area and were concentrated along major urban-industrial and river-development corridors. The Danube–Sava corridor, the broader Belgrade–Novi Sad region, the Velika Morava development axis and the Niš urban-industrial area emerged as principal cumulative-pressure hotspots.

Mapped river-network reductions between 2002 and 2022 reached approximately 20% in Belgrade, 18% in Novi Sad, 15% in Niš and 13% in Pančevo. Urbanization intensity showed a strong inverse association with river-network density (Spearman $\rho = -0.78$, $p < 0.05$). The strongest direct concentration of land sealing, infrastructure development, floodplain occupation and channel modification occurred within 2 km of urban-industrial zones. These results show that national population decline does not necessarily reduce environmental pressure, because people, infrastructure and investment can become increasingly concentrated in a limited number of river corridors.

Climate change adds a second dimension of vulnerability. Drought and prolonged low-flow periods can reduce dilution capacity and increase water-temperature and water-quality stress, whereas intense precipitation can accelerate runoff, erosion, sediment transport and contaminant delivery. Southern and eastern Serbia therefore require attention even where urbanization is lower, because climate-sensitive catchments may combine drought, flood hazards, water scarcity and limited infrastructure. The 2050 planning scenario further suggests that continued development along the northern Serbia–Belgrade–Velika Morava–Niš axis may increase pressure on floodplains, riparian vegetation, drainage connectivity and groundwater-recharge areas.

For climate adaptation, the EEL should be interpreted as a spatial screening layer rather than a regulatory water-quality index. Low EEL areas can guide denser field monitoring, wastewater-control priorities, riparian restoration, sustainable urban drainage, green-blue

infrastructure and floodplain protection. High-value areas should be protected by maintaining forest cover, wetlands, headwater channels and hydrological connectivity. The approach also demonstrates how GIS can connect climate science with societal decision-making by translating heterogeneous environmental information into a transparent map of where intervention is most urgent.

Conclusions

The GIS-based EEI provides a transparent and transferable framework for screening river-system sustainability under land-use and urban-development pressure. Its application to Serbia demonstrates that a slightly positive national mean can conceal extensive local hotspots, particularly along major development corridors. Climate change does not need to be embedded directly in the operational index to be relevant: climate stress can be overlaid as an independent layer that explains where low-flow, drought, intense rainfall and flood conditions may amplify existing anthropogenic pressure. This distinction preserves methodological transparency while strengthening the value of the EEI for climate adaptation and strategic spatial planning.

The principal management message is that land-use planning, river restoration, wastewater management and climate adaptation should be treated together. Repeated EEI calculations, combined with climate projections and field observations, can support early warning, scenario comparison and prioritization of interventions. The framework is particularly useful for national or basin-scale assessment where monitoring networks are incomplete but consistent geospatial data are available.

Acknowledgement

This research was supported by the Ministry of Science of the Republic of Serbia under Grant No. 451-03-34/2026-03/200091. The author also acknowledges the institutions and data providers that supplied the geospatial, hydrological, climatic and statistical datasets used in the study.

References

- Chatrabhuj, Meshram, K., Mishra, U. et al. (2024) Integration of remote sensing data and GIS technologies in river management system' *Discover Geoscience*, 2, 67. <https://doi.org/10.1007/s44288-024-00080-8>.
- Fussmann, K.E., Schwarzmüller, F., Brose, U., Jousset, A. and Rall, B.C. (2014) 'ecological stability in response to warming' *Nature Climate Change*, 4, pp. 206–210. <https://doi.org/10.1038/nclimate2134>.
- Milovanović, B., Stanojević, G. and Radovanović, M. (2022) Climate of Serbia, in Manić, E., Nikitović, V. and Djurović, P. (eds.) *The Geography of Serbia*. Cham: Springer.
- Penny, J., Khadka, D., Alves, P.B., Chen, A.S. and Djordjević, S. (2023) Using multi criteria decision analysis in a geographical information system framework to assess drought risk, *Water Research X*, 20, 100190. <https://doi.org/10.1016/j.wroa.2023.100190>.
- Valjarević, A. (2024) GIS-based methods for identifying river network types and changing river basins, *Water Resources Management*, 38, pp. 5323–5341. <https://doi.org/10.1007/s11269-024-03916-7>.
- Valjarević, A. (2026a) Fluvial geomorphology and GIS-based assessment of water resource vulnerability in oil-affected river systems of Venezuela, *Geomorphology*, 510, 110398. <https://doi.org/10.1016/j.geomorph.2026.110398>.
- Valjarević, A. (2026b) GIS-Based Assessment of Urbanization Impacts on River Network Sustainability, *Water Resources Management*, 40, article 233. <https://doi.org/10.1007/s11269-026-04614-2>.
- Zhou, Q. (2014) A review of sustainable urban drainage systems considering the climate change and urbanization impacts, *Water*, 6(4), pp. 976–992. <https://doi.org/10.3390/w6040976>.

Invited Lectures

[<https://doi.org/10.69646/aob260903>]

[Invited Lecture]

Perceptions and Attitudes Toward Temperature Trends and Climate Change in North Macedonia: A Survey-Based Analysis

Filip Naumovski^{1*}, Marija Ljakoska¹, Emilija Manevska¹, Arse Kuzmanoski¹, Anita Todorova¹

¹Saints Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institute of Geography, Arhimedova 3, 1000 Skopje, North Macedonia

*Correspondence: filipn@pmf.ukim.mk

Abstract: Climate change represents one of the most significant scientific and societal challenges of the 21st century. Understanding public perceptions and attitudes is essential for assessing how societies recognize and respond to climate-related changes. This study investigates how citizens in North Macedonia perceive temperature trends and climate change using a survey-based approach. The questionnaire addressed three main dimensions: perceptions of temperature and climate conditions, knowledge of climate change, and attitudes toward its impacts. The survey was completed by 300 respondents representing different age groups, educational backgrounds, and living environments. The results indicate a high level of awareness, with 88% of respondents considering climate change a serious and real problem and 68% reporting a good understanding of the concept. A clear perception of warming was also evident among respondents, with 59% strongly agreeing that summers are warmer today than in the past, while 65% agreed or strongly agreed that winters are less cold. Furthermore, 81% agreed or strongly agreed that they increasingly observe temperature extremes. Despite this high level of awareness, only 40%

agreed or strongly agreed that their individual actions can contribute to addressing climate change. At the same time, 65% expressed a willingness to gain more information about climate change and its impacts. Overall, the findings suggest that the challenge lies not only in increasing awareness of climate change, but also in strengthening citizens' perceived capacity and willingness to translate awareness into action.

Keywords: temperature trends, climate change, public perceptions, survey, North Macedonia

[<https://doi.org/10.69646/aob260904>]

[Invited Lecture]

On the atomic structure of the seven-times ionized sulfur ion S VIII

Lamia Abu El Maati¹, Nabil Ben Nessib², Milan S. Dimitrijević³

¹Department of Physics, College of Science, Princess Nourah Bint Abdulrahman University, P.O. Box 84428, Riyadh 11671, Saudi Arabia

²Department of Physics and Astronomy, College of Sciences, King Saud University, P.O. Box 2455, Riyadh, 11451, Riyadh, Saudi Arabia

³Astronomical Observatory, Volgina 7, Belgrade 38, 11060, Belgrade, Serbia

*Correspondence: LMAhmed@pnu.edu.sa

Abstract: Seven times ionized sulfur (S VIII) is important in physical and astrophysical research. Some processes involving such ions play an essential role in astronomy, particularly in understanding high-energy astrophysical environments. The atomic properties of these ions can serve as diagnostic tools for the physical conditions in various physical and astrophysical plasmas. In this work, we calculated energy levels and oscillator strengths of the seven times ionized sulfur (S VIII). These atomic parameters were obtained using the Hartree-Fock pseudo-relativistic (HFR) and the Thomas-Fermi-Dirac-Amaldi (TFDA) potential approaches. Results were compared with the NIST-ASD database, Fischer and Tachiev (2004) and Pagan (2011) values. New energy levels and oscillator strengths were determined and can be applied to plasma diagnostics.

Keywords: Energy levels, Oscillator strengths, Seven times ionized sulfur

[<https://doi.org/10.69646/aob260905>]

[*Invited Lecture*]

Tracing the Path from Soil Erosion to Drinking Water Risk: A Modelling Framework for Water Safety Planning

Dejan Vasović^{1*}, Ana Stojanović¹, Sladjan Hristov²

¹University of Niš, Faculty of Occupational Safety, 18000 Niš, Republic of Serbia

²Ministry of Defence, 11000 Belgrade, Republic of Serbia

*Correspondence: dejan.vasovic@znrfak.ni.ac.rs

Abstract: Soil erosion is a major global land degradation process with significant implications for surface water quality, particularly in reservoirs where sediments and associated pollutants accumulate over time. Erosion modelling can therefore support the identification of upstream hazards relevant to drinking-water source protection and Water Safety Planning. Various empirical, semi-empirical, and physically based models are available, but their applicability depends on catchment characteristics and data availability. This study proposes a GIS-based methodological framework using the Erosion Potential Method (EPM), selected for its suitability for catchment-scale assessment under limited data conditions. The framework links spatial patterns of erosion intensity and sediment production with the identification of potential hazards and critical areas within the Water Safety Plan planning process. Its applicability is demonstrated in the Veliki Ržav catchment in Republic of Serbia, an important regional public water resource system. The proposed approach highlights the potential of integrating soil erosion assessment into preventive, risk-based drinking-water management and catchment protection strategies.

Keywords: Soil erosion, Erosion Potential Method (EPM), Reservoir water quality, Water Safety Plans, Catchment management.

Introduction

Soil erosion is among the most significant forms of land degradation, affecting both terrestrial ecosystems and downstream water resources (Milentijević et al., 2021). The detachment and transport of soil particles contribute to increased sediment loads, turbidity, nutrient transport, and the mobilization of contaminants, thereby creating potential pressures on surface water quality (Rodrigo-Comino, 2019). These effects are particularly relevant in reservoir systems, where sediment accumulation may reduce storage capacity and influence the quality and security of water resources intended for multiple uses, including drinking-water supply (Buggiarin et al., 2022). The assessment of soil erosion has therefore become an important component of integrated catchment management (Rodrigo-Comino, Senciales-González and Ruiz-Sinoga, 2020). A variety of empirical, semi-empirical, and physically based approaches are available, including the Universal Soil Loss Equation and its revised forms, WEPP, SWAT-based modelling, and other regionally adapted methods (Liu et al., 2026). However, the applicability of individual models depends on data availability, spatial scale, catchment characteristics, and the intended purpose of the assessment (Debebe, Yirgu and Debele, 2025). For catchments with limited monitoring data, the Erosion Potential Method (EPM) represents a practical approach for estimating erosion intensity and sediment production. This study develops a methodological link between catchment-scale soil erosion modelling and the preventive principles of Water Safety Plans - WSPs (Karkori, 2024). Using the Veliki Ržav catchment in Serbia as an illustrative case, the research applies the EPM within a GIS environment to identify areas of elevated erosion potential and considers their relevance for hazard identification and risk-based source water protection.

Methods and data

The methodological framework was designed to connect spatial soil erosion assessment with the early planning stages of a Water Safety Plan (Mohammed, Gashaw and Yimam, 2025). The Veliki Ržav catchment in Serbia was selected as a case study due to its importance as a regional water resource and the relevance of catchment conditions for downstream water management. Soil erosion was assessed using the Erosion Potential Method (EPM), which estimates the intensity of erosion and potential annual sediment production based on factors describing soil and geological characteristics, land use and vegetation cover, topographic conditions, and visible erosion processes (Chen, 2025). The method uses the following quantitative environmental factors: geological and pedological characteristics, soil cover, coefficient of visible erosion traces, climatic factors (mean annual temperature and mean annual precipitation) and topographic factor. Based on these factors, the erosion coefficient (Z), the total and mean annual production of erosion material (W_{god}), as well as the mean annual volume of total quantities of entrained and suspended sediment (G_{god}) are calculated. Relevant spatial and environmental data were prepared and integrated within a Geographic Information System (GIS). The individual EPM parameters were spatially analyzed and combined to generate an erosion coefficient and classify the catchment according to erosion intensity. The resulting spatial distribution of erosion potential was subsequently interpreted from a water safety and early warning perspective (Vasović, Ristić and Bajrić, 2021). Areas characterized by higher erosion intensity were considered potential upstream hazard zones because of their greater capacity to generate and transport sediment, potentially contributing to increased sediment loads and associated deterioration of downstream water quality. The methodological framework consequently links erosion modelling with hazard identification, the prioritization of critical source areas and the development of targeted preventive catchment protection measures. This approach enables the identification of

locations where soil conservation and land management interventions may be most effective, thereby supporting proactive risk reduction.

Results and discussion

The results of erosion modelling provide information that extends beyond the conventional assessment of soil loss. When interpreted in the context of drinking-water source protection, spatial patterns of erosion intensity can support the identification of areas where land degradation may contribute to increased sediment loads and potential water quality deterioration. This is particularly important for reservoir and accumulation systems, where sediments may be retained and associated pollutants may accumulate over extended periods. The EPM offers particular advantages for this purpose because it can be applied at the catchment scale using comparatively accessible environmental and spatial data. Although more complex models may provide detailed representations of hydrological and sediment transport processes, their application can require extensive calibration and long-term monitoring datasets. The EPM therefore represents a potentially suitable alternative for preliminary assessments and for identifying priority areas requiring further investigation or management intervention. From a Water Safety Plan perspective, the integration of erosion modelling supports a preventive approach by moving risk identification upstream into the catchment. Rather than responding exclusively to changes detected at the reservoir or water treatment stage, erosion-prone areas can be recognized as potential sources of water quality hazards. This information may assist water suppliers and catchment managers in prioritizing monitoring, land management, and erosion control measures.

Conclusions

This study proposes a methodological framework for integrating soil erosion modelling into catchment-based drinking-water safety management. Soil erosion should not be considered exclusively as a land degradation issue, as sediment mobilization may also represent an important upstream pressure affecting reservoir water quality and the reliability of drinking-water resources. The application of the Erosion Potential Method within a GIS environment provides a practical approach for identifying spatial patterns of erosion intensity and potential critical areas within a catchment. Its relatively accessible data requirements make the method particularly relevant for preliminary or screening-level assessments in data-limited environments.

By linking erosion-prone areas with the hazard identification and preventive planning stages of Water Safety Plans, the proposed framework contributes to a more integrated approach to source water protection. The Veliki Ržav catchment demonstrates the potential applicability of this concept within the Serbian context, while the methodology may also be transferable to other reservoir catchments. Ultimately, integrating erosion assessment into Water Safety Planning can support earlier intervention, targeted catchment management, and improved protection of drinking-water resources.

Acknowledgement

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contracts No. 451-03-34/2026-03/200148) in relation to SDG 6, 9 and 11. Part of this publication is based upon work from the Erasmus+ Jean Monnet project „Innovative Ap-proaches to EU Water Policy: Water Innovation for Sustainable and Effective Resilience”—WISER (Ref. No. 101233651).

References

- Rodrigo-Comino, J. (2019). 'Soil erosion as an environmental concern ... for everyone?', *Proceedings*, 30(1), p. 72. doi:10.3390/proceedings2019030072.
- Rodrigo-Comino, J., Senciales-González, J.M. and Ruiz-Sinoga, J.D. (2020). 'The effect of hydrology on soil erosion', *Water*, 12(3), p. 839. doi:10.3390/w12030839.
- Liu, J., Wu, H., Wang, J. and Yan, F. (2026). 'Simulation of soil erosion on the Yunnan–Guizhou Plateau under future climate scenarios based on the SSPs–RUSLE coupled model', *Sustainability*, 18(6), p. 2928. doi:10.3390/su18062928.
- Karkori, F. (2024). 'Water Safety Planning', in *Ship Sanitation, Health and Hygiene. Synthesis Lectures on Ocean Systems Engineering*. Cham: Springer. https://doi.org/10.1007/978-3-031-51667-2_10.
- Chen, C.N. (2025). 'Mapping soil erosion potential and risk for slope land in a watershed', *Terrestrial, Atmospheric and Oceanic Sciences*, 36, 5. <https://doi.org/10.1007/s44195-025-00089-7> (Accessed: 23 August 2026).
- Vasović, D., Ristić, R. and Bajrić, M. (2021). 'Torrent monitoring and early warning systems development: Application and lessons learned', Hershey, PA: IGI Global, pp. 195–216. Available at: <https://doi.org/10.4018/978-1-7998-8459-0.ch010>.
- Mohammed, J.A., Gashaw, T. and Yimam, Z.A. (2025) 'Identification of erosion-prone watersheds for prioritizing soil and water conservation in a changing climate using morphometric analysis and GIS', *Natural Hazards*, 121, pp. 4171–4189. <https://doi.org/10.1007/s11069-024-06952-z>.
- Milentijević, N., Ostojić, M., Fekete, R., Kalkan, K., Ristić, D., Bačević, N. R., Stevanović, V., and Pantelić, M. (2021). Assessment of Soil Erosion Rates Using Revised Universal Soil Loss Equation (RUSLE) and GIS in Bačka (Serbia). *Polish Journal of Environmental Studies*, 30(6), pp.5175–5184. <https://doi.org/10.15244/pjoes/135617>.

Šiljeg, A., et al. (2024). 'Soil Erosion Susceptibility Prediction Using GIS-Based Multicriteria Analysis and Worldview-3 Satellite Images', *Tehnički glasnik*, 18(4), pp. 513-517. <https://doi.org/10.31803/tg-20230425115933>.

Buggiarin, S., Rodighiero, M., Ronco, P., Sottani, A. and Vettorello, L. (2022). 'Hydrogeological modelling and water safety plans: Basic knowledge for the protection of the resource', *Environmental Sciences Proceedings*, 21(1), p. 32. <https://doi.org/10.3390/envirosciproc2022021032>.

Debebe, W., Yirgu, T. and Debele, M. (2025). 'Assessing soil erosion potential for prioritization of land risk area in the Sala watershed of Ari zone, South Ethiopia', *Frontiers in Environmental Science*, 13, 1495923. <https://doi.org/10.3389/fenvs.2025.1495923>.

[<https://doi.org/10.69646/aob260906>]

[*Invited Lecture*]

Hydrological Droughts in the Carpathian Basin: From Historical Evidence to Future Risk under CMIP6 Climate Scenarios

Igor Leščesen^{1*}

¹Institute of Hydrology, Slovak Academy of Sciences, Bratislava, Slovakia

*Correspondence: lescesen@uh.savba.sk

Abstract: This study extends a multi-index (SPI, STI, SPEI, SDI) assessment of hydrological drought across the Carpathian Basin (1961–2024, 36 stations) with new future projections for the Danube River at the Bezdan station under CMIP6 climate scenarios. Historical analysis shows that precipitation (SPI) has remained largely stationary across the basin, while temperature (STI) has warmed significantly at every station, driving a predominantly water-balance (SPEI) and, in small tributary catchments, hydrological (SDI) drying signal; annual SDI at Bezdan itself shows no trend (Kendall's tau = 0.02). Building on this framework, monthly SDI projections (2025–2050) were generated from three CMIP6 general circulation models (CNRM-ESM2-1, EC-Earth3-CC, IPSL-CM6A-LR), bias-corrected against station records, under SSP1-1.9 and SSP5-8.5. Results show moderate-drought frequency roughly doubling under SSP5-8.5 (9–13%) relative to SSP1-1.9 (3–7%), with a severe episode robustly projected across all three models in mid-2026. Low inter-model correlation underscores persistent structural uncertainty, arguing for multi-model, temperature-aware drought monitoring.

Keywords: hydrological drought; Carpathian Basin; CMIP6 projections; Streamflow Drought Index; SSP scenarios

Introduction

The Carpathian Basin constitutes one of Europe's most climatically and hydrologically sensitive transboundary systems, spanning approximately 300,000 km² across nine countries. Home to more than 30 million people and a major agricultural and hydropower zone, the basin faces escalating water stress from rising temperatures, shifting precipitation seasonality, and more frequent compound heat events (Leščešen et al., 2026). A 64-year (1961–2024), 18-station meteorological and 18-station hydrological record across the basin shows that precipitation (SPI) has remained largely stationary, while temperature (STI) has warmed significantly and pervasively at every station (Leščešen, 2026). A critical insight from this research is that drought intensification is driven predominantly by rising evaporative demand rather than precipitation decline: SPEI, which nets precipitation against evapotranspiration, shows a compounding drying signal concentrated where warming is strongest, and SDI shows this stress beginning to express itself hydrologically in small, less-buffered tributary catchments, even while the Danube and Tisza main stems remain broadly stationary in annual terms. While this body of work establishes a robust historical picture of hydrological drought in the basin, how these dynamics will evolve under future climate change remains comparatively unexplored at the catchment scale. This paper extends the existing multi-index framework forward in time, presenting new monthly Streamflow Drought Index (SDI) projections (2025–2050) for the Danube River at the Bezdan gauging station, driven by three CMIP6 general circulation models under contrasting Shared Socioeconomic Pathways. Combining retrospective trend evidence with forward-looking, multi-model projections provides a more complete evidence base, spanning nearly a century of observed change and a quarter-century of projected futures, to inform transboundary drought early-

warning and water-management planning in a basin where climate and society are tightly, and increasingly precariously, interlinked.

Methods and data

The study integrates two complementary components: (i) a historical multi-index drought assessment covering 1961–2024, and (ii) forward-looking, CMIP6-based SDI projections for 2025–2050 at the Bezdan station on the Danube. Historical analysis draws on a 64-year, 1961–2024 hydrological and meteorological dataset, enabling computation of four standardized indices: SPI (meteorological), STI (thermal stress), SPEI (water balance), and SDI (hydrological). Trend detection used the Mann–Kendall test with Theil–Sen slope estimation; homogeneity was assessed via the Pettitt test; and Self-Organizing Maps (SOMs) enabled spatial regionalisation by trend similarity. For the future projection component, monthly precipitation and near-surface air temperature were obtained for three CMIP6 general circulation models, CNRM-ESM2-1, EC-Earth3-CC, and IPSL-CM6A-LR, accessed via the Copernicus Climate Data Store, for the grid cells overlying Osijek, Sombor, and Pécs, the three meteorological stations used as SDI predictors for Bezdan. Model outputs were bias-corrected against 1961–2024 station records, following established regional practice for CMIP6-based downscaling products. Bias-corrected series were used to compute future SPI, STI, and SPEI, which fed a suite of thirteen candidate regression and machine-learning algorithms (including Random Forest, Support Vector Regression, XGBoost, LightGBM, and LSTM) trained on 1961–2024 data to predict SDI at Bezdan; model selection combined cross-validated error metrics (MAE, RMSE, R^2 , NSE, KGE) into a composite ranking. The selected model generated monthly SDI projections for 2025–2050 under two contrasting Shared Socioeconomic Pathways (O'Neill et al., 2017): SSP1-1.9, a strong-mitigation, Paris-Agreement-aligned trajectory, and SSP5-8.5, a high-emission, fossil-fuel-intensive

pathway, following the CMIP6 experimental design (Eyring et al., 2016).

Results and discussion

Over the 1961–2024 observation period, meteorological drought (SPI) across the 18-station network remained essentially stationary: 17 of 18 stations show no significant Mann–Kendall trend, with Budapest the sole exception ($Z = -2.312$, $p = 0.021$). By contrast, the Standardised Temperature Index (STI) warmed unambiguously and significantly at all 18 stations (Z from 6.8 to 14.8, $p \approx 0$), with Sen's slopes of 0.0012–0.0023 STI units/month and abrupt Pettitt change points clustering in the late 1990s to early 2000s. SPEI, which nets precipitation against evapotranspiration, shows a mixed but predominantly drying signal: significant decreasing trends at 6 of 18 stations (Budapest strongest, $Z = -4.325$; also Bjelovar, Zrenjanin, Szombathely, Sremska Mitrovica, and Debrecen), concentrated where warming is strongest. SDI, the hydrological index, shows that this thermally-driven water-balance stress is beginning to express itself hydrologically in small, less-buffered tributary catchments (Čatež on the Sava; Brehy and Holiša in Slovakia), while the Danube and Tisza main stems, including Bezdan, remain broadly stationary in annual terms. At Bezdan specifically, annual SDI shows no trend over 1961–2024 (Kendall's tau = +0.02, $p = 0.792$), effectively the flattest signal of any Danube main-stem station, consistent with its position as an integrative gauge downstream of a large, heterogeneous catchment. Its three meteorological predictor stations, Osijek, Sombor, and Pécs, mirror the basin-wide asymmetry precisely: none shows a significant trend in SPI or SPEI, yet all three show highly significant STI warming (Osijek $Z = 10.4$; Sombor $Z = 11.3$; Pécs $Z = 10.2$; all $p \approx 0$). This predictor-station profile, stable precipitation and net water balance, but unambiguous warming, sets the empirical baseline against which the future SDI projections for Bezdan are read. Projecting forward,

monthly SDI at Bezdan (2025–2050) was generated from three CMIP6 GCMs bias-corrected against the Osijek/Sombor/Pécs 1961–2024 record, under SSP1-1.9 and SSP5-8.5. Under SSP1-1.9, moderate-drought frequency (SDI < -1.0) ranges from 3.2% to 6.5% of months across the three models, broadly consistent with the historically stationary Bezdan SDI record. Under SSP5-8.5, moderate-drought frequency rises to 9.0–12.6%, roughly double, and all three models independently converge on a severe drought episode in mid-2026, with SDI reaching as low as -2.08. This projected intensification reads as a forward extension of the historical asymmetry documented above: precipitation at the Bezdan predictor stations has not systematically declined, but temperature has warmed significantly at all three, and it is this same evaporative-demand mechanism, not an assumed future decline in rainfall, that the SSP5-8.5 projections implicitly encode through elevated temperatures cascading into more frequent SPEI-driven deficits and, ultimately, higher projected SDI drought frequency at Bezdan. Near-zero pairwise correlation between models ($r < 0.10$ in all cases) indicates persistent structural uncertainty in the timing of individual future episodes, even as the models agree directionally that the low-flow regime historically stable at Bezdan through 2024 is projected to become measurably less stable under higher-emission futures, a genuinely new signal relative to the stationary historical record, and one that argues for SPEI-centred, ensemble-based monitoring rather than reliance on any single GCM or index.

Conclusions

Six decades (1961–2024) of multi-index hydrological evidence and a quarter-century of CMIP6-based projections converge on the same central finding for the Carpathian Basin: rising evaporative demand, not precipitation decline, is the primary driver of intensifying drought. Precipitation (SPI) remains stationary at 17 of 18 stations, while

temperature (STI) has warmed significantly at all 18, and SPEI and SDI both show this asymmetry compounding into water-balance and, in small tributary catchments, hydrological drought, even as annual SDI at Bezdan itself, and along the Danube and Tisza main stems more broadly, remains statistically stationary. This same asymmetry is encoded in the future projections: moderate-drought frequency at Bezdan roughly doubles under SSP5-8.5 relative to SSP1-1.9, and all three CMIP6 models, despite otherwise limited agreement, converge on a severe drought episode in mid-2026, flagging a concrete near-term risk window for transboundary water management on the Danube. Persistent structural uncertainty between GCMs, and the historically stationary annual SDI signal at Bezdan itself, argue against reliance on any single model, station, or index. Multi-index, multi-model, temperature-aware drought monitoring and forecasting frameworks, integrating both retrospective trend evidence and forward-looking ensemble projections, constitute the most robust operational basis for anticipating and managing hydrological drought risk across the Carpathian Basin's shared river systems.

References

- Eyring, V., Bony, S., Meehl, G.A., Senior, C.A., Stevens, B., Stouffer, R.J. and Taylor, K.E. (2016) Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. *Geoscientific Model Development*, 9(5), pp.1937–1958.
- Leščešen, I. (2026) *Droughts in the Carpathian Basin*. Institute of Hydrology, Slovak Academy of Sciences: Bratislava.
- O'Neill, B.C., Kriegler, E., Ebi, K.L., et al. (2017) The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change*, 42, pp.169–180.

[<https://doi.org/10.69646/aob260907>]

[*Invited Lecture*]

Continentality Indices as a Common Language for Climate and Society: A Precipitation Seasonality - Case Study Babušnica (Serbia) - Sofia (Bulgaria) 1961-2020

Jelena Svetozarević^{1*}

¹Climate, Atmosphere and Water Research Institute at Bulgarian Academy of Sciences, Sofia, Bulgaria

*Correspondence: jelena.svetozarevic09@gmail.com

Abstract: Modern climatology produces a large amount of data, while society experiences climate through concrete impacts: when it rains, how long the dry season lasts, and whether the water comes all at once or evenly. Simple quantitative metrics can bridge this gap. This study proposes four complementary indices describing precipitation concentration, seasonality and climatic continentality - PCI (Oliver), SI (Walsh and Lawler), PCD/PCP (Zhang), and Shver K - for monthly precipitation from Babušnica (485 m) and Sofia (550 m) for 1961- 2020. Both stations show a moderate-seasonal regime. Babušnica: mean 675.5 mm, PCI 11.38, SI 0.47, PCD vector 0.17, PCP 195° (July), K 52.9%. Sofia: 597.5 mm, PCI 11.72, SI 0.50, PCD 0.22, K 60.1% - more continental.

Comparing 1961-1990 vs 1991-2020, annual totals remain stable (Babušnica 674.3→676.8 mm; Sofia 576.3→616.1 mm). Concentration trends diverge: Babušnica shows a slight increase (PCI 11.34→11.43, SI 0.46→0.47) with a 14° shift of PCP to late May (188°→202°); Sofia shows a slight decrease (PCI 11.86→11.62, SI 0.51→0.49, PCD 0.24→0.20).

These indices translate directly into societal information: adjustments to the sowing calendar, irrigation needs, and seasonal water storage.

They provide a visual, understandable tool for agriculture, water management, and transboundary early warning and more.

Keywords: PCI, PCD/PCP, seasonality, continentality, precipitation, climate-society bridge

References

- Kendall, M.G., 1975. *Rank correlation methods*. 4th ed. London: Charles Griffin.
- Mann, H.B., 1945. Nonparametric tests against trend. *Econometrica*, 13(3), pp. 245–259.
- Oliver, J.E., 1980. Monthly precipitation distribution: A comparative index. *The Professional Geographer*, 32(3), pp. 300–309.
- Shver, C.A., 1976. *Atmospheric precipitation on the territory of the USSR*. Leningrad: Gidrometeoizdat.
- Walsh, R.P.D. and Lawler, D.M., 1981. Rainfall seasonality: Description, spatial patterns and change through time. *Weather*, 36(7), pp. 201–208.

Lectures

[<https://doi.org/10.69646/aob260908>]

[Lecture]

Heat Waves in Rural Regions of Serbia: Who is the Most Vulnerable?

Natalija Nikolić^{1*}, Milica Vasić¹

¹University of Novi Sad, Faculty of Sciences, Department of Geography, Tourism and Hotel Management, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia

*Correspondence: natalija.nikolic@dgt.uns.ac.rs

Abstract: Heat waves (HWs) represent extreme climate events and one of the deadliest natural hazards globally. While the effects of HWs in urban areas have been extensively studied, their impacts on rural populations remain comparatively underexplored. This study aims to highlight the challenges faced by rural populations in Serbia during HWs and identify the most vulnerable areas from a demographic perspective. Rural population accounts for 38% of Serbia's total population and inhabits approximately 88% of its territory. It is slightly older than the urban population, with an average age of 45.25 years, compared to 43.00 years in urban areas. The difference is particularly pronounced in Southern and Eastern Serbia, where the average age of the rural population reaches 51.85 years, 7.24 years higher than that of the urban population of the same region. Zaječar, Bor, and Pirot Areas have the oldest rural populations, with ageing indices of 422.5, 405.2, and 370.1, respectively. Rural healthcare infrastructure is also less developed, with smaller settlements often lacking local medical facilities or pharmacies. The lowest numbers of physicians per 100,000 inhabitants are recorded in several predominantly rural municipalities, including Mionica (42), Nova Crnja (62), and Čoka (72), compared to the country's average of 323. Moreover, many

agricultural workers, who predominantly reside in rural areas, spend substantial amounts of time outdoors, increasing their exposure to extreme heat. During HWs, prolonged exposure to unusually high temperatures can further increase the risk of heat-related health effects, particularly among individuals with limited physiological or social capacity to cope with extreme heat. These demographic, healthcare, and occupational characteristics suggest that rural populations in Serbia may face heightened vulnerability during HWs. Future research should combine field-based temperature measurements, assessments of residents' thermal comfort, and comparisons between rural and urban environments to provide a comprehensive assessment of heat-related health risks in Serbia.

Keywords: heat-related health risks, rural regions, population ageing, Serbia

Acknowledgement

The authors gratefully acknowledge the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grants No. 451-03-33/2026-03/ 200125 & 451-03-34/2026-03/ 200125).

[<https://doi.org/10.69646/aob260909>]

[Lecture]

Trend of air temperature at the meteorological station Vranje during the period 1949-2024

Tijana Radosavljević^{1*}, Sanja Manojlović¹

¹Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia

*Correspondence: tijana.radosavljevic.2000@gmail.com

Abstract: In this research, the temperature trends were analyzed at meteorological station Vranje for the period 1949-2024. The study aims to determine the trend in air temperature on annual, seasonal, and monthly levels and to determine the change point in the time series. The non-parametric Mann-Kendall test and Pettitt test were used. Based on the processed data and the obtained results, it can be concluded that the trend of annual, monthly and seasonal air temperatures is increasing. The air temperature increases annually by about 0.019°C ($\alpha=0.001$). A statistically significant trend was determined in July ($\alpha=0.1$) and in the summer period of the year ($\alpha=0.05$). A statistically significant trend of temperature increase occurred at the meteorological station Vranje after 1997. The results of air temperature trend research are of great scientific and practical importance for future urban and rural planning, but also for the projection of future trends and the creation of climate models.

Keywords: Air temperature trend, Vranje, Mann-Kendall, Pettitt test

Introduction

Climate change is the subject of numerous studies around the world. In recent years, anthropogenic influence has increasingly been included as the main factor in the positive trend of climate elements, although there is evidence of natural climate variability (Miletić et al., 2025). Ten years ago, estimates were that human influence led to an increase in global average air temperature of between 0.4° and 0.8°C

over the course of a century (Malinović-Milićević et al, 2014). Current estimates, for the period 2011-2020, are that global temperature increased by 1.1°C compared to the period 1850-1900, as a result of increased greenhouse gas emissions, but also inadequate land use, modern human lifestyles and the disproportionate ratio of energy production and consumption (IPCC, 2023). According to estimates by the National Aeronautics and Space Administration (NASA), rising temperatures will lead to an enhanced water cycle, which leads to increased evaporation. Increased evaporation further leads to more frequent and intense storms, but also contributes to the aridification of certain areas on land (Durlević et al., 2021). The increase in air temperature at the global level is reflected in all elements of the geographical envelope, and the consequences of climate change can be felt in many regions of the world through rising sea levels, melting glaciers, forest fires, and increasingly frequent and severe droughts. All of this significantly affects the living world, primarily human health and living in general, but also the social aspects of human activity (Sadhukhan et al., 2023).

Serbia is one of the countries that has faced significant changes in air temperature values over the past thirty years. As for the rest of the world, there are general forecasts for Serbia, which predict that the entire region of southern Europe will be affected by high temperatures and subsequent periods of drought. In almost all parts of Serbia, trends of increasing air temperature have been observed since 1949 and ending with 2020 (Sedlak et al., 2024). Some authors have linked atmospheric patterns over the Atlantic Ocean, such as the North Atlantic Oscillation (NAO), the East Atlantic Pattern (EA), with changes in temperature regimes in Serbia during winter and summer (Malinović-Milićević et al., 2015), while in the South Morava Valley the influence of the Mediterranean Oscillation has been analyzed (Miletić et al., 2025). Putniković (2025) linked the influence of atmospheric circulation types that are associated with the distribution of air masses with climatic conditions in Serbia.

This study aims to assess long-term temperature trends and to identify the transition year at the Vranje meteorological station, based on time series data covering the period 1949–2024, analyzed at annual, seasonal, and monthly scales. The results of this research can serve both local authorities and the highest state bodies as a clear insight into the trends of climate parameters, in order to take appropriate measures.

Methods and data

The study area includes data from meteorological station Vranje ($\varphi=42^{\circ}33'$, $\lambda=21^{\circ}55'$) in Southern Serbia, in subregion of Southern Pomoravlje. Station is located at an altitude of 432 meters. According to Köppen's climate classification, Vranje is located in the area of a moderately warm and humid climate with a warm summer (Cfb) (Milovanović et al., 2017). The climate of Vranje is characterized by great dryness, which resulted in the separation of a separate, Vranje climatic region. The longest drought period in Serbia was recorded in Vranje – 61 days (21.06.-21.08.1928) (Драгићевић и Филиповић, 2016). The weather conditions in Vranje during the summer are influenced by the activities of the Icelandic cyclone and the Azores anticyclone. Air masses from the northern part of the Atlantic, moving eastward and across the Adriatic Sea, pass through the territory of Serbia, along the Sava and Danube valleys, in late spring and early summer. During the summer, the southern part of Europe is exposed to the influence of anticyclonic air masses over the Azores Islands, which bring dry and warm weather. In the cold period of the year, Serbia is exposed to the influence of the Siberian anticyclone and cyclonic conditions over the Mediterranean (Gulf of Genoa) (Milovanović et al., 2017).

The data on annual and monthly air temperature values at the selected meteorological station were taken from the meteorological yearbooks of the Hydrometeorological Institute of the Republic of Serbia for the period 1949-2024 (<https://www.hidmet.gov.rs/>). The data on seasonal air temperature values are grouped in such a way

that December (from the previous calendar year), January and February belong to the winter season, March, April and May to the spring season, June, July and August to the summer season and September, October and November to the autumn. The winter of 1949 was not taken into account.

The research was conducted using non-parametric tests, the Mann-Kendall and Pettitt tests (Mann, 1945, Kendall, 1975). The Mann-Kendall test is used for the analysis, determination and decomposition of time series. This type of test has wide application in geographical research. The Mann-Kendall test is based on the correlation between the level of values of the series and their chronological order. The null hypothesis assumes that there is no trend in the selected series, and the alternative that there is a statistically significant trend (upward or downward). The Pettitt test is used to determine the year of transition, i.e. the period when significant changes in the trend of the analyzed parameters occurred (Sedlak et al, 2024; Tošić et al., 2025).

Results and discussion

During the observed period 1949-2024, the average temperature was 11.28°C. The maximum average annual temperature was recorded in 2024 and was 13.6°C, and the lowest 9.8°C in 1976. The annual trend of air temperature is constantly increasing (Figure 1). The trend value (z) is 4.075, while the Sen's estimate is 0.019. These results show that the air temperature is increasing by 0.019°C per year on average.

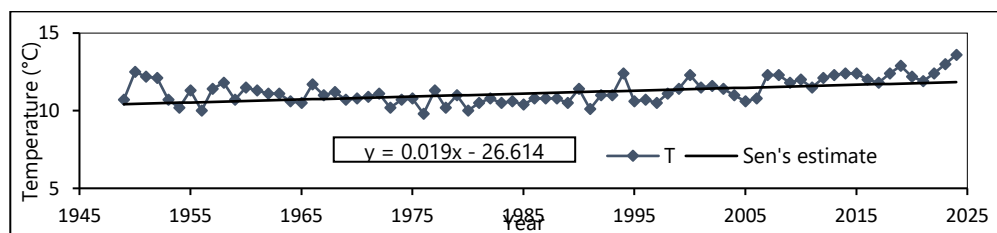


Figure 1. Result of Mann-Kendall test for annual air temperatures in Vranje for the period 1949-2024

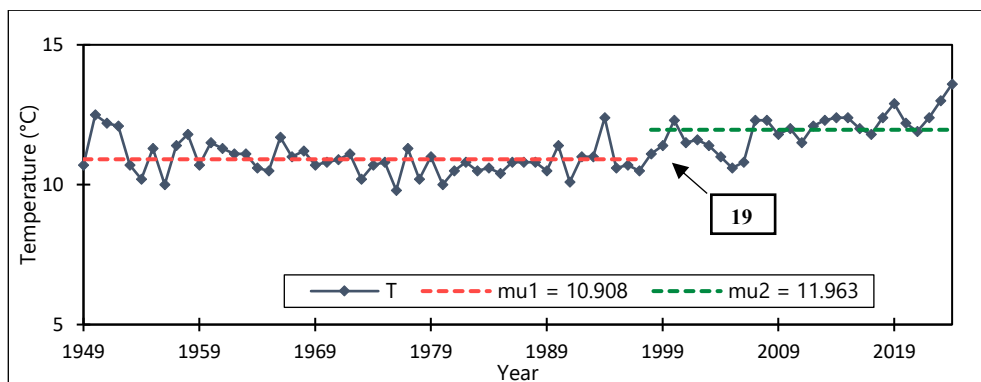


Figure 2. The transition year detected using the Pettitt test for annual air temperatures in Vranje for the period 1949-2024

By applying the Pettitt test (Figure 2), 1997 stands out as the year of significant change in annual air temperature. In the period 1949-1997, the average annual air temperature in Vranje was 10.91°C, and during the period 1997-2024, the average air temperature is 11.96°C, which is an increase of 1.05°C.

Table 1. Trend of seasonal air temperature values in Vranje (1949-2024) using the Mann-Kendall and Pettitt test

Season	Spring	Summer	Autumn	Winter
<i>b</i>	0.088**	0.130***	0.026	0.079*
<i>Y</i>	1998	1991	2007	2006

*Significance: * $\alpha=0.001$, ** $\alpha=0.01$, *** $\alpha=0.05$; *b* – Sen's slope, *Y* – transition year

At the seasonally level (Table 1), the most statistically significant trend was observed in the summer period of the year, then during spring and less significant during winter. Autumn is without statistical significance. The trend value during summer is 3.658, while the Sen's estimate is 0.130, i.e., summer temperatures, on average, increase by 0.130°C per year. Spring temperatures increase by 0.088°C per year, and winter temperatures by 0.079°C on average. The results of the Pettitt test coincide with the results of the Mann-Kendall test. Spring, summer, and winter again stood out as the seasons with significant changes.

The warmest months in Vranje are July and August with an average temperature of 21.6°C. The coldest month is January with an average temperature of -0.1°C and is the only month with a negative average air temperature. The highest July temperature was measured in 2012 at 25.4°C, and the lowest temperature was measured in January 2017 at -5.2°C.

Table 2. Trend of monthly air temperature values in Vranje (1949-2024) using the Mann-Kendall and Pettit test

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
<i>b</i>	0.133	0.300	0.583*	0.213*	0.210	0.140	0.293**	0.267*	0.100	0.050	-0.120	-0.190
<i>Y</i>	1993	2006	1973	1997	1993	1992	1992	1991	2010	1997	2007	2007

*Significance: * $\alpha=0.001$, ** $\alpha=0.01$, *** $\alpha=0.05$; *b* – Sen's slope, *Y* – transition year

At the monthly level (Table 2), several statistically significant changes in air temperature were observed, of which the July temperature was the most significant. A trend with lower statistical significance was recorded in March, April and August, while the other months did not show significant changes. The air temperature in July increases by 0.293°C per year, which is a trend with higher statistical significance. Air temperatures in March, April and August increase by 0.21-0.58°C per year and are less significant. A negative trend was observed during November and December, where the temperature decreased on average by 0.1-0.2°C per year, but without statistical significance. The result of the Pettitt test coincides with the results obtained by the Mann-Kendall test. For these months, 1991 (August) and 1992 (July) stand out as the years of change. The only deviation is observed in the February and June values. The years of change are 1992 (June) and 2006 (February), however, no significant statistical trend was observed.

A significant change in air temperature was observed at all levels in Vranje. The last decade of the 20th and the first decade of the 21st century stand out as periods of significant trend changes. The trend in air temperature can be explained by the movement of air masses,

but also by the influence of atmospheric patterns on the climate of Serbia.

Conclusions

The paper analyzes annual, seasonal and monthly air temperature trends at the Vranje meteorological station, using the Mann-Kendall and Pettitt tests, for the period 1949-2024. At the annual level, a significant increase in temperature was observed. At the monthly level, a significant trend was observed over four months, of which July temperatures stand out in particular. Observed seasonally, the most significant change is during the summer period, while greater significance is also observed during spring and winter. At all levels, temperature changes have been more intense over the last thirty-five years. Such air temperature trends in Vranje can be explained by the general movements of large air masses and patterns, which affect weather conditions in this part of Europe.

The results obtained may be significant for planning measures and regulations to protect or reduce the impact of climate change on human health and in general all spheres of social life and activity. In order to conduct a complete analysis, it is necessary to examine trends in other climate elements, such as precipitation, air pressure, humidity, and wind. In this way, it is possible to more precisely determine whether and how significant climate changes are.

References

- Durlević, U., Sedlak M., Ćorović, N. (2021). Trend godišnjih i sezonskih količina padavina na klimatološkoj stanici Loznica. *Zbornik radova mladih istraživača Jedanaestog naučno-stručnog skupa sa međunarodnim učešćem „Planska i normativna zaštita prostora i životne sredine”*. Vršac. str. 47-53.
- IPCC. (2023). Climate change 2023. *Synthesis Report*. pp. 4-5.
- Kendall, M., G. (1975). *Rank Correlation Methods*. 4th ed. London: Charles Griffin

- Malinović-Miličević, S., Radovanović, M. Stanojević, G., Milovanović, B. (2015). Recent changes in Serbian climate extreme indices from 1961 to 2010. *Theoretical and Applied Climatology*, Vol. 120, No. 3-4. Springer.
- Mann, H., B. (1945). Non-parametric tests against trend. *Econometrica*, Vol. 13, No. 3. The Econometric Society. pp. 163-171.
- Miletić, M., Ducić, V., Mihajlović, J. (2025). Impact of the Mediterranean oscillation on climate elements and streamflow in the South Morava river basin. *Collection of paper of Faculty of Geography*, Vol. LXXIII. Belgrade: Faculty of Geography. pp. 23-43.
- Milovanović, B., Ducić, V., Radovanović, M., Milivojević, M. (2017). Climate regionalization of Serbia according to Köppen climate classification. *Collection of paper of Geographical Institute „Jovan Cvijić“ SASA*, 67 (2). Belgrade: Serbian Academy of Science and Art – Geographical Institute „Jovan Cvijić“. pp. 103-114.
- Milovanović, B., Schuster, P., Radovanović, M., Vakanjac-Ristić, V., Schneider, C. (2017). Spatial and temporal variability of precipitation in Serbia for the period 1961-2010. Wien: Springer-Verlag.
- Putniković, S. (2025). Influence of Atmospheric Circulation on Seasonal Temperatures in Serbia. *Atmosphere*, 16 (8). Basel: MDPI. pp. 969-984.
- Sadhukhan, B., Mukherjee, S., Samanta, K., R. (2023). A Study of Global Temperature Anomalies and their Changing Trends due to Global Warming. *14th International Conference on Computational Intelligence and Communication Networks (CICN)*. Saudi Arabia. pp. 1-6.
- Sedlak, M., Manojlović, S., Srejić, T. (2024). Air temperature trends in Eastern Serbia 1961-2020. *International conference Milanković's theory of climate changes – Hundred years afterwards*. Belgrade: Association Milutin Milanković.

Tošić, I., Alves da Silva, S., A., Filipović, L., Tošić, M. Lazić, I., Putniković, S., Stošić, T., Stošić, B., Djurdjević, V. (2025). Trends of Extreme Precipitation Events in Serbia Under the Global Warming. *Atmosphere*, 16 (4). pp. 2-18.

Драгићевић, С., Филиповић, Д. (2016). *Приордни услови и непогоде у планирању и заштити простора*. Београд: Географски факултет. стр. 184-187.

[<https://doi.org/10.69646/aob260910>]

[Lecture]

Review of the COST networking activities - modifications of the rules and introduction of new opportunities for ITC participants

Zoran Mijić¹, Bratislav Marinković¹

¹Institute of Physics Belgrade, Pregrevica 118, Belgrade, Serbia

*Correspondence: zoran.mijic@ipb.ac.rs, bratislav.marinkovic@ipb.ac.rs

Abstract: Serbia is a full member of COST (European Cooperation in Science and Technology), the oldest intergovernmental organization in Europe that aims to establish research networks among scientists and innovators (Marinković et al., 2022). COST actions are designed to ensure networking opportunities for researchers and include a wide range of activities and grants that help individuals establish new collaborations, developing joint research topics, and supporting scientific and personal career development. Many researchers view COST as an extremely valuable European funding instrument due to its unique people-centered approach, which prioritizes researchers over institutions. Serbia belongs to the group of Inclusiveness Target Countries (ITC) whose researchers have additional mechanisms at their disposal for financing activities within COST networks (Mijić and Marinković, 2024). During the four-year lifetime of the COST action, there are many instruments available to researchers, and some of the most frequently used will be introduced in detail, such as organizing workshops and meetings, short-term scientific missions (STSMs), training schools, conference grants, communication and dissemination grants, and virtual mobility grants. Particular focus will be on available participation opportunities for young researchers and innovators and the introduction of novel COST rules, such as a limit of working group membership coming into force as of November

2026. A brief review of recently approved COST research networks and available leading positions will be presented together with a description of new procedures and limitations for submitting action proposals within the current open call OC2026. These rules mandate that young researchers must make up at least 40% of the COST action composition, and an individual researcher can participate as a secondary proposer in only one new action proposal.

Keywords: science inclusiveness, action networking tools, mobility and visibility

Acknowledgement

Thanks are due to The Ministry of Science, Technological Development and Innovation of the Republic of Serbia and the Institute of Physics Belgrade for national COST office support.

References

- Marinković P.B., Ivanović S., Mijić Z. 2022. Data analysis on Serbian participation in COST Actions: Celebrating 50 years of research networks, IV Meeting on Astrophysical Spectroscopy - A&M DATA – Atmosphere, 49-57, Palić, Serbia, 30 May – 2 June, 2022.
- Mijić, Z., Marinković, B. 2024. Participation of Serbian researchers in COST activities and an overview of COST procedures and national rules for joining recently approved COST actions, VI Conference on Active Galactic Nuclei and Gravitational Lensing, 34-35, Zlatibor, Serbia, 2-6 June, 2024.

[<https://doi.org/10.69646/aob260911>]

[Lecture]

Air Pollution as a Driver of Population Mobility: Empirical Evidence and Underlying Mechanisms

Milica Langović¹, Zoran Vidović²

¹Institute of Physics Belgrade, University of Belgrade, Serbia

²Faculty of Education, University of Belgrade, Serbia

*Correspondence: milica.langovic@ipb.ac.rs

Abstract: This study examines the impact of air quality on migration intentions and potential destination choices, using empirical data from field surveys conducted in the City of Belgrade, Serbia, in 2025. Employing advanced statistical modeling within the R programming environment, the findings provide critical insights into both current demographic trends and future trajectories. The analysis reveals a significant correlation between air pollution and population migration intentions and identifies spatial patterns of potential mobility at both domestic (rural–urban frameworks) and international scales. These findings expand the existing literature by highlighting the necessity of analyzing urban migration within the context of specific, localized external pressures experienced by residents over time. By addressing potential future prospects, this research establishes a vital foundation for subsequent investigations into environmental migration in Serbia.

Keywords: migration, air quality, City of Belgrade, Serbia

Acknowledgement

This work was funded by the Institute of Physics Belgrade, University of Belgrade, through a grant by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia.

[<https://doi.org/10.69646/aob260912>]

[Lecture]

VLF amplitude noise reductions as earthquake precursors: statistical analysis

Aleksandra Nina¹, Pier Francesco Biagi², Giovanni Nico³, Hans U. Eichelberger⁴, Mohammed Y. Boudjada⁴

¹Institute of Physics Belgrade, National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

²Department of Physics, University of Bari, Bari, Italy

³Institute of Applied Mathematics, Italian National Research Council, Bari, Italy

⁴Space Research Institute, Austrian Academy of Sciences, Graz, Austria

*Correspondence: sandrast@ipb.ac.rs

Abstract: Many studies point to the possibility of connecting different types of changes with seismic activity. Their detection before an earthquake is the subject of decades of research that attempts to confirm that they are earthquake precursors. One of the methods of relevant changes detection is the low ionosphere monitoring by radio signals of very low and low frequencies (VLF/LF signals). Several specific changes in these signals are considered as possible precursors of earthquakes (Hayakawa, 2025). Among them is the reduction in the amplitude noise reduction, which was first shown for the Mw 5.4 earthquake that occurred near Kraljevo, Serbia on November 3, 2010 (Nina et al, 2020). Pilot studies have confirmed this change in the case of other earthquakes as well (Nina et al, 2022; Nina, 2024).

In this paper, we present the first statistical study of amplitude noise reductions before earthquakes. We observe the ICV signal emitted in Italy and received in Serbia. The obtained results indicate that the connection between amplitude noise reductions and earthquakes is more pronounced for larger magnitudes, smaller depths of

earthquake hypocentres, and smaller distance of the earthquake epicentres from the signal path. Bearing in mind that these characteristics are expected for changes associated with seismic activity, it can be concluded that the presented statistical analysis confirms the possibility that the amplitude noise reductions are precursors of earthquakes, thus indicating the need to continue their research.

Keywords: earthquake precursors, VLF signal, statistical analysis

Acknowledgement

The authors acknowledge the support of COST Action CA24101 FuSe: Testing Fundamental Physics with Seismology. Aleksandra Nina acknowledges funding provided by the Institute of Physics Belgrade through the grant by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

References

- Hayakawa, M. (2025) Review of Subionospheric VLF/LF Radio Signals for the Study of Seismogenic Lower-Ionospheric Perturbations. *Atmosphere*, 16(11), 1312. <https://doi.org/10.3390/atmos16111312>
- Nina, A., Pulinets, S., Biagi, P.F., Nico, G., Mitrović, S.T., Radovanović, M., & Popović, L.Č. (2020) Variation in natural short-period ionospheric noise, and acoustic and gravity waves revealed by the amplitude analysis of a VLF radio signal on the occasion of the Kraljevo earthquake ($M_w = 5.4$). *Science of The Total Environment*, 710, 136406. <https://doi.org/10.1016/j.scitotenv.2019.136406>
- Nina, A., Biagi, P. F., Pulinets, S., Nico, G., Mitrović, S. T., Čadež, V. M., Radovanović, M., Urošev, M., & Popović, L. Č. (2022) Variation in the VLF signal noise amplitude during the period of intense seismic activity in Central Italy from 25 October to 3 November 2016. *Frontiers in Environmental Science*, 10, 1005575. <https://doi.org/10.3389/fenvs.2022.1005575>

Nina, A. (2024) Analysis of VLF Signal Noise Changes in the Time Domain and Excitations/Attenuations of Short-Period Waves in the Frequency Domain as Potential Earthquake Precursors. *Remote Sensing*, 16(2), 397. <https://doi.org/10.3390/rs16020397>

[<https://doi.org/10.69646/aob260913>]

[Lecture]

Climate Aridity Changes and Their Impact on Agricultural Production - Case Study: South Serbia

Filip Krstić^{1*}, Mirjana Gajić¹

¹Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia

*Correspondence: filip.krstic@gef.bg.ac.rs

Abstract: This paper analyzes climate aridity trends in South Serbia and their agricultural impacts across two periods (1961–1990 and 1991–2024). Meteorological data from five stations (Niš, Leskovac, Vranje, Dimitrovgrad, and Kuršumlija) were used to calculate the Lang rain factor, Emberger index, and Selyaninov hydrothermal coefficient. The results indicate rising summer temperatures, prolonged growing seasons, and localized aridity increases. While the hilly-mountainous region periphery and Leskovac basin remain stable due to increased precipitation counterbalancing thermal stress, the Vranje basin exhibits significant aridification, with declining values across all indices.

Keywords: aridity, climate, South Serbia, Emberger index, Selyaninov coefficient

Introduction

The increase in air temperature, the variability of the amount of precipitation in terms of pluviometric regime and the increasing pressures of socioeconomic factors have influenced the assessment of droughts and climate aridity to become important topics both at the global and regional levels. In the context of global climate change, it is necessary to analyse the factors that influence the

change in aridity, but also the occurrence of extreme climatic phenomena such as heat waves, extreme precipitation, floods and droughts (Gocić et al., 2025; Burić et al., 2023).

Due to the change in temperature regime and precipitation regime, there is a change in the aridity of the climate in a certain area. A significant lack of precipitation, in relation to the average values for a certain territory, is the main cause of the drought. Drought differs from other natural disasters, because its duration is significantly longer and it covers large areas. The consequences of drought are long-lasting and have a complex impact on the reduction of water resources and the weaker adaptation of both natural ecosystems and society as a whole (Trajković, 2019). Unlike drought, which is a temporary phenomenon, aridity is a permanent feature of the climate and occurs in areas with a low amount of precipitation, and is a consequence of the general circulation of the atmosphere, relief and other climatic regional factors (Maliva and Missimer, 2012).

The subject of research in the paper is the change in climate aridity in the area of South Serbia and its impact on agricultural production. South Serbia is a region whose natural boundaries can be identified with the South Morava drainage basin. The South Morava valley represents the morphological backbone of this region, while the peripheral parts of the region are hilly and mountainous.

According to Köppen's climate classification, the South Morava valley belongs to the modified continental type of climate (Cfw'ax). The mountain rim of the region belongs to the modified temperate-continental climate type (Cfw'bx). The highest parts of the region, such as the Vlasina plateau, Kukavica, Suva and Radan mountain, belong to the subalpine climate (Dfw'bx) (Gajić and Krstić, 2025).

The analysis of aridity in South Serbia is important because it has an intensive agricultural production of the main crops (maize, wheat), with significant production of fruits and vegetables. Given that most of the land is not irrigated, agriculture is highly dependent on climatic conditions. A decrease in precipitation is often accompanied by high temperatures in the summer, greater evaporation and

insolation, which leads to a significant decrease in soil moisture. This causes water stress in agricultural crops and results in reduced yields.

Methods and data

Climatological parameters for five synoptic weather stations in South Serbia were used to determine the climate aridity trend. The selected stations are located in basins where agricultural production is the most intensive and which have the best quality agricultural soil in the region. The stations Niš, Leskovac and Vranje are located in the valley of South Morava, and the stations Dimitrovgrad and Kuršumlija are located in the valleys of the largest tributaries of South Morava - Nišava and Toplica, respectively.

The paper analyzed climatological data for the period 1961–2024. In order to determine the change in climate aridity, the data are divided into two climatological periods. The first period is from 1961–1990, and the second period 1991–2024. The data were chosen in order to include the longest possible period of measurement and to include the entire lowland and basin area of South Serbia. The data were taken from the meteorological yearbooks of the Republic Hydrometeorological Service of Serbia. Gocic and Trajkovic (2014) regionalized Serbia according to drought vulnerability. The region of South Serbia belongs to the P3 region of moderate precipitation with an average of about 630 mm per year. This region also records a slightly higher frequency of extreme droughts.

For the purposes of determining the trend of aridity and climate-related lack of moisture, several indicators were used. Lang's rainfall index (I_L) represents the ratio between the annual amount of precipitation and the mean annual air temperature. This index in South-Eastern Europe more often records a drop in value during the summer months, which indicates an increased aridity of the climate.

Emberger index (I_E) unlike simple aridity ratios, measures the relationship between water availability and atmospheric evaporation by utilizing temperature extremes and annual rainfall. The formula for this index is:

$$IE = \frac{2000 \cdot P}{M^2 - m^2}$$

where the parameters represent: P - total mean annual precipitation in mm; M - average maximum temperature of the hottest month; m - average minimum temperature of the coldest month. Both average temperatures are converted to Kelvin.

Selyaninov's hydrothermal coefficient (HTC) is a bioclimatic index designed to evaluate agricultural drought and moisture availability during the active plant growing season. The formula for this coefficient is:

$$HTC = \frac{10 \cdot \Sigma P}{\Sigma T}$$

where the parameters represent: ΣP - the sum of daily precipitation in mm over the active growth season; ΣT - the sum of active daily average air temperatures in °C over active growth season; 10 - scaling factor applied to represent the temperature sum in a simplified potential evaporation format.

Results and discussion

According to the results of Lang's rainfall index for two climatological periods (1961-1990 and 1991-2024), all stations, with the exception of Leskovac, recorded a slight decrease in this index, which indicates an increase in aridity. The stations Niš, Leskovac and Vranje are located in the semiarid zone, while the stations on the periphery of the region, Dimitrovgrad and Kuršumlija, are in the subhumid or moderately humid zone. According to the Emberger index, the entire area of Southern Serbia is characterized by a subhumid climate (values between 60 and 100).

The only station that recorded a significant increase in this index is Leskovac, due to a noticeable increase in humidity, i.e. an increase in the total annual amount of precipitation. On the other hand, the Vranje station recorded a significant increase in aridity, because temperatures during the summer months increased significantly, and

the amount of precipitation remained the same during both climatological periods. Also, all stations have a trend of significantly milder winters, which also affects the value of this index.

Table 1. Values of Lang Rainfall index (I_l), Emberger index (IE) and Selyaninov's hydrothermal coefficient (HTC)

Station	I_l		IE		HTC	
	1961-1990	1991-2024	1961-1990	1991-2024	1961-1990	1991-2024
Niš	51.8	49.1	64.6	65.2	0.96	0.95
Leskovac	55.1	57.2	61.2	66.8	0.99	1.06
Vranje	57.0	52.3	65.0	61.3	1.05	0.99
Dimitrovgrad	65.4	63.7	69.8	69.9	1.22	1.22
Kuršumlja	63.7	63.0	70.6	71.2	1.18	1.21

The values of Selyaninov's coefficient show that the region of South Serbia is on the margin of an arid and slightly arid climate. Changes in the thermal regime affect a lower risk of freezing in the winter, but also a significantly higher heat stress of agricultural crops in the summer. Also, the entire region is characterized by the extension of the vegetation period, due to higher temperature sums (for example, at the Leskovac station, the temperature sums increased by about 214°C).

Stations in South Serbia also recorded the largest increase in mean monthly and maximum temperatures during July and August, which significantly increases evapotranspiration. What stands out as an advantage, especially at the Leskovac, Kuršumlja and Dimitrovgrad stations, is that the increase in the amount of precipitation during the growing season compensates for the increase in thermal energy.

Conclusions

The analysis of the aridity trend for the area of South Serbia clearly shows that climate changes are taking place in the direction of a

significant increase in summer temperatures (both minimum, maximum and average) and an increase in the sum of effective temperatures during the growing season. Agricultural production, however, depends on the local trend of precipitation, with the hilly and mountainous areas of the region being in a much better position. At most stations, the increase in annual precipitation, as well as precipitation during the growing season, manages to match or overcome heat stress, while soil moisture remains satisfactory. The Vranje basin in the south of the region, however, records a significant increase in aridity, which requires special adjustment measures and the use of irrigation in agricultural production.

References

- Burić D., Mihajlović J., Ducić V., Milenković M., Anđelković G. (2023) Contribution to the study of climate change in Serbia using continentality, oceanity and aridity indices, *Időjárás* 127(3), 379–399.
- Gajić, M. and Krstić, F. (2025) *Geografija Srbije* 1, Beograd: Univerzitet u Beogradu – Geografski fakultet.
- Gocić, M., Milentijević, N., Ivanović, M., Tošić, I., Živanović, S., Martić Bursać, N., Stričević, Lj. (2025) Spatial and temporal variability of aridity indices in the region of Souther and Eastern Serbia, *Theoretical and Applied Climatology*, 156.
- Gocic, M., Trajkovic, S., (2014) Spatiotemporal characteristics of drought in Serbia, *Journal of Hydrology* 510, 110–123.
- Maliva, R., Missimer, T. (2012) *Arid Lands Water Evaluation and Management, Environmental Science and Engineering*, Springer-Verlag, Berlin, Heidelberg,
- Meteorološki godišnjak I (1961-2024). Beograd: Savezni hidrometeorološki zavod (do 1990); Republički meteorološki zavod (od 1991).

Trajković, S. (2019) *Prostorno-vremenske karakteristike suša u Srbiji. In Geohazard u Srbiji u 21. veku – znanje je najbolji bedem protiv stihije. Ciklus predavanja / Srpska akademija nauka i umetnosti, knj. 5. Beograd: Srpska akademija nauka i umetnosti, 25–41.*

[<https://doi.org/10.69646/aob260914>]

[Lecture]

Is climate sufficiently present in the classroom? An analysis of content and outcomes on climate change in Geography curricula in primary schools

Ivana Đorđević^{1*}, Mina Marković¹, Slavoljub Jovanović¹

¹Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia

*Correspondence: ivana.djordjevic@gef.bg.ac.rs

Abstract: The aim of the paper is to examine climate change content representation by analysing the programme and the results of the study of content on climate change in the teaching of Geography in the second cycle of basic education in Serbia. The research is based on an analysis of the content of valid Geography curricula and the identification of learning outcomes that are directly or indirectly related to climate change, its causes, consequences and mitigation options. The results show that climate change content is present in the analysed programmes, but that its representation is insufficient and uneven, and that it appears through specific content and learning outcomes. The findings indicate the need for a more systematic inclusion of climate change in Geography curricula, a clearer connection with learning outcomes, and the development of more concrete methodological guidelines for its treatment in teaching.

Keywords: climate change, Geography curricula, outcomes, primary school

Introduction

Climate change education is an increasingly important part of contemporary educational policies and curricula, with its representation and treatment varying between education systems and subjects. Research covering several countries shows that climate change is not equally represented in Geography curricula, which indicates the importance of analysing their content and learning outcomes (Dawson et al., 2022). The special role of geography lies in its ability to connect natural processes with the spatial, ecological and social consequences of climate change (Enke, Budke, 2023). At the same time, the treatment of climate change content requires an interdisciplinary approach that recognises the specific contribution of different subjects to understanding this complex problem (Eilam, 2022). Due to this complexity, there is an increasing need for the correlation of scientific disciplines that address these issues. Interdisciplinarity can be seen as a way to increase the efficiency of the pedagogical process in all subjects, with the aim of independent acquisition of knowledge, improving the quality of functional knowledge and forming the well-rounded personalities of students (Živković et al., 2017). Within overall institutional education, primary school is considered the most important because children attend it at an age when they are most open to new knowledge (Živković, Jovanović, 2011). In this context, analysing how content and outcomes related to climate change are represented in Geography curricula is a significant step towards understanding the place of this topic in primary education.

Methods and data

The school system is shaped by legal acts, Geography curricula and educational standards in the domain of student achievement, which are binding for all participants in the teaching process (Živković, Jovanović, 2011). The empirical structure of the work includes determining the representation of the content and outcomes of learning about climate change in Geography curricula for elementary

schools. By analysing the Geography curricula in the second cycle of primary education in Serbia, a comprehensive insight is gained into the extent to which the content of climate change is studied. The tasks of the research were:

- analysing the representation of educational outcomes for the end of primary school, programme content and instructions for implementing programmes in the field of climate change;
- formulating proposals that can contribute to greater representation of content on climate change and its treatment in Geography curricula in primary schools.

The sample consisted of the Regulations on the teaching and learning plan for the fifth and sixth grades of primary education and the teaching and learning programme for the fifth and sixth grades of primary education (Official Gazette of the Republic of Serbia, 15/2018-77, 18/2018-1, 3/2019-83, 3/2020-3, 6/2020-94, 17/2021-1, 16/2022-1, 13/2023-458, 14/2023-384, 3/2024-1, 6/2025-7, 1/2026-219), and the Regulations on the teaching and learning plan for the seventh and eighth grades of primary education (Official Gazette of the Republic of Serbia, 18/2018-1, 13/2023-469, 1/2026-339).

The paper used a descriptive method, which involves comparing, evaluating and interpreting the results obtained through content analysis of the Geography curricula in elementary school, as well as drawing conclusions.

Results and discussion

Given the importance of primary education in acquiring knowledge and forming attitudes and values, the inclusion of climate content in the Geography curricula is one of the key prerequisites for developing students' environmental awareness. The modern Geography curriculum for the fifth to eighth grades of primary school is based on learning outcomes, which represents a significant change compared with previous programmes that were focused primarily on teaching content. The focus of teaching is on student achievements, that is, the knowledge, skills and competences that students need to

develop, while the teaching content is provided as a recommendation for achieving these outcomes.

Of a total of 46 outcomes specified in the Geography curriculum for the *fifth grade* of primary school, seven are directly related to climate change content, which accounts for 15.2%. They include developing students' ability to distinguish between responsible and irresponsible use of natural resources, recognising the causes and consequences of atmospheric and water pollution, explaining the occurrence and consequences of floods and torrents, knowing appropriate behaviour during and after floods, understanding the impact of human activity on threats to plant and animal species, and providing examples of measures to protect living things.

Compared with the fifth grade curriculum, the *sixth grade* places greater emphasis on research-based learning and project-based teaching, which encourages students to participate actively in the teaching process and apply the knowledge they have acquired in analysing problems in their immediate environment. Of the 17 outcomes prescribed by the programme, two, or 11.8%, are directly related to content on climate change and sustainable development. Students are expected to relate the spatial distribution of economic activities to environmental quality, and to assess the possibilities of applying the principles of sustainable development in the local community, the Republic of Serbia, Europe and the world.

Of the 20 defined outcomes in the Geography curriculum for the *seventh grade* of elementary school, three (15%) are directly focused on environmental issues, including content on climate change. Students are expected to analyse examples of positive human actions aimed at protecting nature and preserving the environment, and to compare them with examples from their own environment. They should also evaluate possible solutions for the use of clean energy sources in countries whose economic development is traditionally based on the exploitation of fossil fuels, primarily oil and coal.

In the Geography curriculum for the *eighth grade* of primary school, four of the 22 outcomes envisaged by the programme are directly

related to climate change, which accounts for 18.2%. By the end of the eighth grade, the student should be able to participate in proposing and implementing a research project in the local environment. In addition, the student should be able to analyse the impact of climate factors and elements on the climate of Serbia. Finally, the student should be able to recognise the effects of physical and geographical processes on humans, as well as the effects of the production and use of various energy sources on environmental quality, and to respond appropriately in the event of natural disasters.

Based on an analysis of curricular content and learning outcomes related to environmental protection in geography education in the second cycle of primary education, several proposals have been formulated that could contribute to a greater representation of climate change content and its treatment in the Geography curricula in primary schools.

The first proposal concerns the need for a more systematic and continuous inclusion of climate change content across different grades. Climate change content should not be addressed only within individual teaching topics or grades; rather, its inclusion should be planned in such a way that students gradually broaden and deepen their understanding of the causes, consequences, and spatial dimensions of climate change.

The second proposal involves establishing clearer links between climate change content and learning outcomes. In addition to acquiring factual knowledge, learning outcomes should encourage students to analyse the spatial and temporal dimensions of climate change, interpret relevant geographical data, critically evaluate different sources of information, and consider possibilities for adapting to and mitigating the consequences of climate change.

The third proposal concerns the need for more specific methodological guidelines for teachers regarding the teaching of climate change content. Such guidelines could include the use of geographical data and maps, analysis of local and regional examples,

interpretation of climate change-related trends, comparison of different geographical areas, as well as the application of problem-based and inquiry-based learning. The aforementioned proposals do not imply the introduction of a separate school subject or an entirely new thematic area. Rather, they call for the more systematic integration of climate change content into the existing Geography curricula, accompanied by more clearly defined learning outcomes and appropriate methodological guidelines for their implementation in teaching practice.

Conclusions

Based on the analysis of the programme and the results of the study of climate change content in the teaching of Geography in the second cycle of primary education in Serbia, the paper highlights its insufficient representation. Bearing in mind the identified shortcomings, it is necessary, in order to improve the educational value of the Geography curricula in elementary school, to increase the number of outcomes related to the study of climate change content. To improve teaching practice, proposals were formulated for modifying the existing Geography curricula for elementary school. These proposals include a more systematic and continuous integration of climate change content across different grades, clearer alignment of such content with learning outcomes, and the provision of more specific methodological guidelines for teachers. The practical implications of the research lie in the fact that the presented results and conclusions can encourage textbook authors to change their approach when designing content on climate change.

The subject of climate change deserves continuous analysis, in order to determine more precisely the criteria for designing the Geography curricula in accordance with the goals and tasks of education. A limitation of this study is that the analysis focuses on the education system of the Republic of Serbia and on the second cycle of primary education, which limits the direct generalizability of the findings to other education systems and educational cycles. Future research

could extend the analysis to other educational cycles, as well as to the curricula of other countries.

Acknowledgement

This work was funded by the Faculty of Geography, University of Belgrade, through a grant from the Ministry of Science, Technological Development and Innovations of the Republic of Serbia (Contract number 451-03-34/2026-03/200091).

References

- Dawson, E., Eilam, E., Tolppanen, S., et al. (2022). A cross-country comparison of climate change in middle school science and geography curricula. *International Journal of Science Education*, 44(9), 1379–1398. <https://doi.org/10.1080/09500693.2022.2078011>
- Eilam, E. (2022). Climate change education: The problem with walking away from disciplines. *Studies in Science Education*, 231–264. <https://doi.org/10.1080/03057267.2021.2011589>
- Enke, N., Budke, A. (2023). Preparing students for a changing world: How geography curricula in Europe are tackling climate change. *Frontiers in Education*, 8. <https://doi.org/10.3389/feduc.2023.1216780>
- Regulations on the teaching and learning plan for the fifth and sixth grades of primary education and the teaching and learning programme for the fifth and sixth grades of primary education. Official Gazette of the Republic of Serbia, 15/2018-77, 18/2018-1, 3/2019-83, 3/2020-3, 6/2020-94, 17/2021-1, 16/2022-1, 13/2023-458, 14/2023-384, 3/2024-1, 6/2025-7, 1/2026-219.
- Regulations on the teaching and learning plan for the seventh and eighth grades of primary education. Official Gazette of the Republic of Serbia, 18/2018-1, 13/2023-469, 1/2026-339.
- Živković, Lj., Jovanović, S. (2011). Environmental education and geography teaching in elementary school. *Bulletin of the Serbian Geographical Society*, 59, 255–280.

Živković, Lj., Jovanović, S., Đorđević, I., Golubović, N. (2017). An interdisciplinary approach to geography teaching content in elementary school. *Bulletin of the Serbian Geographical Society*, 97(1), 137-158.

[<https://doi.org/10.69646/aob260915>]

[Lecture]

Semantic Orchestration for Time-Domain Astronomy

Veljko Vujčić^{1*}

¹Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia

*Correspondence: veljko@aob.rs

Abstract: Time-domain astronomy relies on heterogeneous data from telescopes, surveys, detectors, archives, and value-added alert brokers. Those instruments may capture the same astronomical phenomena, yet their data interfaces and response structures differ, as do their identifiers and semantic conventions. We present Alertissimo, a research prototype for the semantic orchestration of heterogeneous astronomical data services. At its core, a hierarchical semantic model assigns provider-neutral, serialization-independent addresses to astronomical entities, measurements, classifications, associations, and data products. Reusable concepts are composed into typed records whose context distinguishes the role of each value, while provenance and explicit relationships between records are preserved in canonical, object-centric Portfolios. Alertissimo supports provider-agnostic scientific workflows that are expressed through a domain-specific language (DSL) and compiled into a typed intermediate representation independent of any particular broker or service. The principal contribution is an executable semantic layer that decouples scientific intent from provider interfaces without depending on the universal adoption of a single standard or serialization. It also provides a deterministic target for future natural-language interfaces: a language model may translate user requests into the DSL.

Keywords: astronomy, Alertissimo, DSL

Posters

[<https://doi.org/10.69646/aob260916>]

[Poster]

Statistical Methods for Analysing Environmentally Induced Migration Intentions

Zoran Vidović^{1*}

¹Faculty of Education, University of Belgrade, Serbia

*Correspondence: [*zoran.vidovic@uf.bg.ac.rs](mailto:zoran.vidovic@uf.bg.ac.rs)

Abstract: This paper presents the statistical methodology applied in research on the relationship between air pollution and migration intentions in Belgrade. Descriptive statistics were used to summarize respondents' socio-demographic characteristics and migration attitudes. The chi-square test and Cramér's V coefficient were applied to examine associations between categorical variables and assess their strength. Spearman's correlation and the Kruskal–Wallis test were used to analyse ordinal variables and differences between independent groups. Logistic regression models were employed to identify significant predictors and estimate the probability of migration intentions. The paper demonstrates the practical value of combining these methods in demographic and environmental research.

Keywords: methodology, statistical methods, migration, air pollution

[<https://doi.org/10.69646/aob260917>]

[Poster]

Correlation between air temperature and air pollution in the city of Skopje

Emilija Manevska^{1*}, Arse Kuzmanoski¹, Filip Naumovski¹, Anita Todorova¹, Marija Ljakoska¹

¹Ss. Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institute of Geography, Arhimedova 3, 1000 Skopje, North Macedonia

*Correspondence: emilijamanevska@pmf.ukim.mk

Abstract: Air pollution represents one of the major environmental challenges in the city of Skopje, with pollutant concentrations exhibiting considerable temporal variability. Meteorological conditions, particularly air temperature, can influence the concentration and dispersion of air pollutants. This study focuses to examine the relationship between air temperature and air pollutants in the city of Skopje during the ten-year period from 2012 to 2021.

The analysis is based on average monthly air temperature and average monthly concentrations of the major air pollutants SO₂, NO_x, PM_{2.5}, PM₁₀, CO, and O₃, taken from five air quality monitoring stations in the Skopje agglomeration. The relationship between air temperature and the concentration of each pollutant is investigated using the Pearson correlation coefficient. The analysis is conducted by monitoring station in order to identify the direction and strength of the linear relationship between temperature and individual air pollutants and to examine spatial differences within the study area.

The results provide insight into the extent to which variations in air temperature are associated with variations in pollutant

concentrations in Skopje. Particular attention is given to pollutants that exhibit stronger positive or negative correlations with temperature and to differences in correlation patterns among monitoring locations. The findings contribute to a better understanding of the relationship between climatic conditions and air quality in Skopje and may provide a basis for further research on the factors influencing air pollution in the city.

Keywords: Correlation, air pollution, air temperature, Skopje

[<https://doi.org/10.69646/aob260918>]

[Poster]

Ionospheric Disturbances & Machine Learning: VLF Signal Variation Detection and Perspectives

Peter Bednár¹, Aleksandra Nina², Aleksandra Kolarski^{2*}, Peter Butka¹, Martin Sarnovský¹, Vladimir A. Srećković², Ognyan Kounchev³

¹Institute of Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 1/9, 042 00 Košice, Slovakia

²Institute of Physics Belgrade, National Institute of the Republic of Serbia, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

³Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Geo Milev, ul. "Akad. Georgi Bonchev" 8, 1113 Sofia, Bulgaria

*Correspondence: kolarski@ipb.ac.rs

Abstract: Very Low Frequency (VLF; 3-30 kHz) radio signals' variations recorded in Belgrade (Serbia) were investigated by utilization of different machine learning techniques, in order to examine their possible relation to different types of natural hazards. Both VLF amplitude and phase data were inspected in time- and frequency-domain, revealing detectable data patterns with promising future research directions. Main findings are presented here.

Keywords: VLF signals, ionospheric disturbances, machine learning

Acknowledgement

The Institute of Physics Belgrade, University of Belgrade, supported this work with a grant from the Republic of Serbia's Ministry of Science, Technological Development, and Innovations. Authors acknowledge funding in the frame of the Serbian – Slovak bilateral project "AI in Practice: Automatic Detection of VLF/LF Ionospheric Disturbances using Machine Learning" (project no. 001147721/010)

and multilateral scientific and technological cooperation in the Danube region "Application of novel AI methods (Transformer Architectures) in analyzing Big data in Astrophysics (ionospheric and geomagnetic) and Physics (molecular magnetism)" DS2 (project no. 003614304 2025 13440 003 000 000 001 01 005).

[<https://doi.org/10.69646/aob260919>]

[Poster]

The Astro-Geo Interface: Prospects and Directions for Future Research

Milica Langović^{1*}, Vladimir A. Srećković¹, Georgi Boyadjiev², Ognyan Kounchev², Hans U. Eichelberger³, Georgi Simeonov²

¹Institute of Physics Belgrade, University of Belgrade, Serbia

²Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Geo Milev, ul. "Akad. Georgi Bonchev" 8, 1113 Sofia, Bulgaria

³Space Research Institute, Austrian Academy of Sciences, Graz, Austria

*Correspondence: milica.langovic@ipb.ac.rs

Abstract: Building on existing research demonstrating that solar activity governs numerous terrestrial geographical processes, this study explores future directions for interdisciplinary research in the astro-geographical field. Given that all natural phenomena are inherently interconnected, establishing cascading causal chains across multiple earth-system elements offer new perspectives on terrestrial changes that are often examined in isolation from broader solar influences. Accordingly, this work investigates the linkages among both natural and social geographical elements, contextualizing them within the framework of overarching solar forcing. As research of this kind remains in its early stages (e.g., Langović et al., 2025), further methodological development is essential to fully elucidate these complex terrestrial processes. Ultimately, this study proposes a foundational framework for this interdisciplinary domain, highlighting the critical need to develop robust methodological tools for future investigations.

Keywords: interdisciplinary research, solar activity, geosciences, Sun, Earth

Acknowledgement

The Institute of Physics Belgrade, University of Belgrade, supported this work with a grant from the Republic of Serbia's Ministry of Science, Technological Development, and Innovations. Authors acknowledge funding in the frame of the multilateral scientific and technological cooperation in the Danube region "Application of novel AI methods (Transformer Architectures) in analyzing Big data in Astrophysics (ionospheric and geomagnetic) and Physics (molecular magnetism)" DS2 (project no. 003614304 2025 13440 003 000 000 001 01 005).

Reference

Langović, M., Srećković, V., Vidović, Z., Langović, M. & Mijić, Z. (2025). The nexus between solar activity and population displacement: The case study of Southern Europe. Journal of the Geographical Institute Jovan Cvijic, SASA, 1-17. <https://doi.org/10.2298/IJGI250621017L>

[<https://doi.org/10.69646/aob260920>]

[Poster]

Assessment of Long-Term River Discharge Variability and Precipitation Coherence: The South Morava River, Serbia

Marko Langović^{1*}, Nenad Živković¹, Slavoljub Dragičević¹

¹ Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia

*Correspondence: marko.langovic@gef.bg.ac.rs

Abstract: Long-term hydrological records provide an important basis for understanding how climate variability is reflected in river discharge. This study examines the relationship between precipitation variability and river discharge cycles in the South Morava River Basin (Serbia), over a 100-year period (1924–2023). Mean and maximum annual discharges at the downstream Mojsinje hydrological station were analysed in relation to annual total precipitation and maximum daily precipitation recorded at five representative meteorological stations across the basin. Cross-spectral analysis was applied to identify common periodic components and their coherence. For that purpose, statistical method of cross-spectral analysis was performed. The results reveal pronounced spatial differences in precipitation–discharge system. Stronger and more consistent coherence was identified between mean annual values, whereas relationship between maximum values were weaker and more spatially heterogenous. The findings can provide a basis for broader research on the relationship between climate variability, climate change and river discharge, while also offering useful insights for future water-resource management.

Keywords: river discharge, climate variability, cycles, South Morava River

Introduction

Climate change and direct human impacts affect hydrological cycle and the availability of both groundwater and surface water resources. Hydrological variations and river regimes are primarily influenced by variations in temperature and precipitation, as well as by frequency and magnitude of extreme events (Blöschl et al., 2019; Bărbulescu et al., 2025). Consequently, understanding long-term river discharge variability and its characteristics has become increasingly important for human activities, integrated water management, environmental protection and natural hazard assessment.

Long hydrological records are particularly valuable because they enable short-term fluctuations to be distinguished from multi-decadal variability and provide an opportunity to investigate whether recurrent patterns in river discharge are associated with corresponding climatic oscillations (Melnik et al., 2025). Previous studies have demonstrated that long-term discharge series may contain multi-year and multi-decadal cycles, although their periodicity vary considerably among catchments (Pekarova et al., 2021).

The South Morava River Basin represents an appropriate case study due to the availability of an almost century-long hydrological record and its spatially heterogeneous climatic conditions. A previous comprehensive analysis identified significant differences in discharge trends and cyclicity along the river course (Langović et al., 2023). Building on these findings, the present contribution focuses specifically on precipitation–discharge relationship. The main objective is to examine relationship between precipitation variability and river-discharge cycles on the example of the South Morava River, Serbia, using a 100-year period (1924–2023).

Methods and data

Hydrological data included mean annual discharge (Q_{mean}) and maximum annual discharge (Q_{max}) at the Mojsinje hydrological

station for the period 1924-2023. Discharge data were obtained from the Hydrological yearbooks of the RHSS.

Meteorological data were obtained from stations distributed across the South Morava River Basin. Five representative stations - Niš, Leskovac, Vranje, Kuršumljia, and Vlasina – were selected for detailed analysis.

Cross-spectral analysis was applied to investigate common periodic components and the strength coherence between hydrological and precipitation time series in the frequency domain (Wang and Worman, 2019). The climate – hydrology relationship was analyzed using multiple correlation. This approach enabled the identification and comparison of dominant precipitation–discharge periodicities at different temporal scales. The statistical analysis was performed in the JASP/R environment.

Results and discussion

The obtained results revealed pronounced differences in precipitation-discharge coherence among the analyzed meteorological stations. Mean annual discharge and annual precipitation showed a stronger and consistent relationship, with statistically significant cross-spectral coherence identified at all five stations. A common cycle of approximately 17-20 years was particularly evident at four stations (Vranje, Leskovac, Niš and Kuršumljia). Other significant periodicities varied spatially, including approximately 8–12 years at Vranje, 5 years at Vlasina and Kuršumljia, and 7–8 years at Niš. These differences indicate considerable spatial heterogeneity in precipitation–discharge coupling within the South Morava River Basin.

In contrast, maximum annual discharge and maximum daily precipitation generally showed weaker and less consistent cross-sectoral relationship. The most pronounced exception was Leskovac, where significant coherence was identified at approximately 8-year and 17-20-year periods. At the other stations, significant components were either absent, as in the case of Vranje, or concentrated mainly

withing short 2-3-year periods, which does not necessarily mean repeatability of the time series..

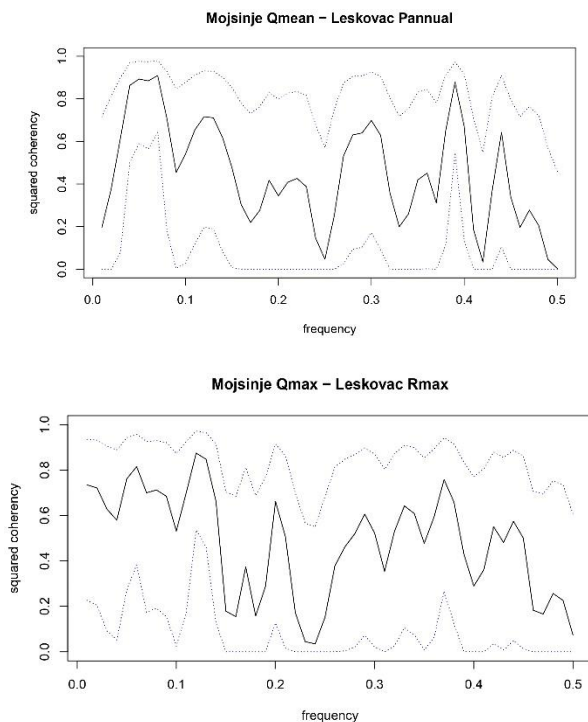


Figure 1 – Cross-spectral coherence between discharge at HS Mojsinje and precipitation at MS Leskovac: (a) $Q_{\text{mean}} - R$, and (b) $Q_{\text{max}} - R_{\text{max}}$

Overall, the results confirm the importance of precipitation as a major factor controlling long-term discharge variability, while indicating a clearer relationship with mean then with maximum annual discharge. Mean discharge represents an integrated response of the basin to precipitation over longer periods. On the contrary, maximum annual discharge reflects individual events that occur once or more times a year without the regularity of their occurrence. Likewise, the direct influence on discharge depend also on external factors such as the current bankfull discharge and water level, height of snow cover in the basin, anthropogenic endangerment of the riverbed, etc.

Furthermore, the maximum daily precipitation registered at an individual station does not necessarily correspond spatially or temporally to the event responsible for the annual maximum discharge at HS Mojsinje. This difference may partly explain the weaker and more spatially heterogeneous coherence observed for maximum values.

Conclusion

The main objective of this study was to examine the statistical relationship between mean and maximum annual discharge of the South Morava River and precipitation characteristics obtained from five meteorological stations within the basin. The results showed significant and relatively consistent cross-spectral coherence between mean annual discharge and annual precipitation, including a 17–20-year cycle identified at most analysed stations. At the same time, secondary periodicities differed considerably between stations, indicating pronounced spatial variability.

In contrast, maximum annual discharge and maximum daily precipitation showed weaker and less consistent periodic relationships. This suggests that hydrological extremes are controlled by a more complex combination of meteorological and basin conditions and therefore exhibit lower temporal regularity.

Future research should extend the analysis to additional hydrological stations within the South Morava River Basin and include seasonal discharge and precipitation variability, as well as the potential influence of large-scale atmospheric circulation patterns.

Acknowledgement

This work was supported by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia (Contract number: 451-03-34/2026-03/200091).

References

- Bărbulescu, A., Costache, R. & Dumitriu, C. (2025). Climate Change and Hydrological Processes. *Water*. 17, 1474. <https://doi.org/10.3390/w17101474>
- Blöschl, G., Hall, J., Viglione, A. et al. (2019). Changing climate both increases and decreases European river floods. *Nature*, 573, 108–111. <https://doi.org/10.1038/s41586-019-1495-6>
- Melnyk, S., Vasiutynska, K., Butenko, O., Korduba, I., Trach, R., Pryshchepa, A., Trach, Y. & Protsiuk, V. (2026). Time Series Analysis and Periodicity Analysis and Forecasting of the Dniester River Flow Using Spectral, SSA, and Hybrid Models. *Water*. 18, 291. <https://doi.org/10.3390/w18020291>
- Langović, M., Živković, N., Dragičević, S. & Luković, J. (2023). Repeatability cycles of river discharges: Can we identify discharge patterns? A case study of the South Morava River (Serbia). *Carpathian Journal of Earth and Environmental Sciences*, 18(2), 369–383. <https://doi.org/10.26471/cjees/2023/018/266>
- Pekarova, P., Meszaros, J., Miklanek, P., Pekar, J., Proharska, S. & Ilić, A. (2021). Long-term runoff variability analysis of rivers in the Danube Basin. *Acta Horticulturae et Regiotecturae*, 37–44. <https://doi.org/10.2478/ahr-2021-0008>
- Wang, J. & Wörman, A. (2019). Spectral analysis of river resistance and aquifer diffusivity in a river-confined aquifer system. *Water Resources Research*, 55, 8046–8060. <https://doi.org/10.1029/2018WR024639>

[<https://doi.org/10.69646/aob260921>]

[Poster]

Spatial Distribution of Floods and Earthquakes in Southern Europe: An Analysis at the NUTS 3 Regional Level (1990–2025)

Luka Đurović^{1*}

¹ Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia, PhD student

*Correspondence: luka.djurovicgeos@gmail.com

Abstract: Natural hazards represent a significant risk factor for societies in Southern Europe, a region exposed to both seismic activity and frequent hydrological extremes. This paper analyzes the spatial distribution of two dominant types of natural hazards—floods and earthquakes—across the territories of Southern European countries: Italy, Spain, Portugal, Greece, Serbia, Croatia, Slovenia, Bosnia and Herzegovina, Montenegro, North Macedonia, and Albania, over the period from 1990 to 2025. Data on hazard events, obtained from the EM-DAT database, were georeferenced and represented as points in QGIS software, and subsequently aggregated at the NUTS 3 statistical regional level (or NUTS 3-equivalent regions for the territory of Bosnia and Herzegovina). Based on the number of events recorded in each region, hazard density is calculated in relation to regional area, thereby identifying spatial patterns of concentration (hotspots) for each hazard type separately. Particular attention is given to comparing the spatial distribution of floods and earthquakes, with the aim of determining whether regions exposed to one type of hazard overlap with those exposed to the other, or whether the two risks are spatially complementary. The results are expected to demonstrate pronounced spatial heterogeneity across the study area, with earthquakes concentrated

in zones of elevated seismic activity, while floods are expected to be more closely associated with river basins and lowland areas. The findings may provide a basis for further risk assessment and the planning of preventive measures at the regional level.

Keywords: natural hazards, floods, earthquakes, spatial distribution, Southern Europe

[<https://doi.org/10.69646/aob260922>]

[Poster]

Big Data Analysis in Astrophysics and Physics: A Multidisciplinary Approach

Vladimir A. Srećković¹, Georgi Boyadjiev², Ognyan Kounchev²,
Aleksandra Kolarski¹, Milica Langović¹, Aleksandra Nina¹, Zoran Mijić¹,
Hans U. Eichelberger³

¹Institute of Physics Belgrade, National Institute of the Republic of Serbia,
University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

²Institute of Mathematics and Informatics, Bulgarian Academy of Sciences,
Geo Milev, ul. "Akad. Georgi Bonchev" 8, 1113 Sofia, Bulgaria

³Space Research Institute, Austrian Academy of Sciences, Graz, Austria

*Correspondence: vlada@ipb.ac.rs

Abstract: The rapid growth of observational and computational datasets creates new challenges for the detection and interpretation of transient phenomena. This work in progress investigates the application of modern artificial intelligence methods, particularly Transformer architectures and attention mechanisms, to Big Data in astrophysics, ionospheric and geomagnetic physics, and molecular magnetism. Our current work focuses on long-term VLF observations of the ionosphere, containing signatures of solar flares, coronal mass ejections, solar energetic particle events, lightning, and other transient phenomena. We are developing Transformer-based models for the automatic detection and characterization of ionospheric disturbances using time- and frequency-domain information. In parallel, the approach is being explored for atomic and molecular datasets, with particular emphasis on molecular magnetism and the prediction of magnetic properties. The ongoing work aims to establish a transferable AI framework for heterogeneous scientific Big Data and demonstrate its potential for space-weather research and computational physics.

Keywords: Big Data, Artificial Intelligence, Transformer Models, Space Weather

Acknowledgement

The Institute of Physics Belgrade, University of Belgrade, supported this work with a grant from the Republic of Serbia's Ministry of Science, Technological Development, and Innovations. Authors acknowledge funding in the frame of the multilateral scientific and technological cooperation in the Danube region "Application of novel AI methods (Transformer Architectures) in analyzing Big data in Astrophysics (ionospheric and geomagnetic) and Physics (molecular magnetism)" DS2 (project no. 003614304 2025 13440 003 000 000 001 01 005).

[<https://doi.org/10.69646/aob260923>]

[Poster]

Recent Solar Activity: A Preliminary Analysis Based on Cosmic-Ray Observations

Nikola Veselinović¹, Mihailo Savić¹, Darije Maričić², Mila Ranitović³,
Dejan Joković¹, Radomir Banjanac¹, Žarko Medić¹

¹Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

²Astronomical Observatory Zagreb, Opatička 22, 10000 Zagreb, Croatia

³University of Novi Sad, Department of Physics, Novi Sad, Serbia

*Correspondence: veselinovic@ipb.ac.rs

Abstract: Space weather describes variable conditions in the near-Earth environment driven by solar activity, which can affect technological systems and human activities. Solar Cycle 25 has remained highly active during 2025–2026, characterized by frequent solar flares, coronal mass ejections, and disturbances in the solar wind. Changes in the magnetic environment carried by the solar wind modulate galactic cosmic rays propagating through the heliosphere, producing measurable variations in cosmic-ray intensity at Earth. In this contribution, we present a preliminary analysis of cosmic-ray variations during 2025–2026 using observations from the Belgrade Muon Station, operated by the Low-background Laboratory for Nuclear Physics (LBLNP) at the Institute of Physics, University of Belgrade, together with data from other ground-based stations. Cosmic-ray muon variations are examined in relation to solar activity and solar-wind parameters measured both in situ and at ground level, with particular focus on transient solar and interplanetary disturbances. The results provide a complementary ground-based approach to investigating solar activity and space-weather phenomena.

Keywords: space weather, cosmic rays, solar activity, Belgrade muon station

[<https://doi.org/10.69646/aob260924>]

[Poster]

Process-based insights into lateral channel migration and riverbank erosion under climate variability

Marko Langović¹

¹ Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia

*Correspondence: marko.langovic@gef.bg.ac.rs

Abstract: Climatic drivers influencing the intensity of lateral channel migration and riverbank erosion processes operate through two main mechanisms: through their influence on hydrological variability (Aktar, 2013), and through long-term effects on other factors such as soil, vegetation, and anthropogenic activities within the river basin (Langović et al., 2024). Climatic causes should therefore not be examined separately from hydrological factors, as both groups of factors form part of the same cause-and-effect system. Considering them together provides a better understanding of changes in the intensity of riverbank erosion and lateral channel migration. Key climatic indicators include maximum precipitation, the number of days with rainfall exceeding 10 mm, and temperature fluctuations. Previous studies in the Kolubara and South Morava River basins (Dragićević et al., 2014; Langović, 2024) have demonstrated the significance of these indicators, primarily through their influence on hydrological conditions and associated extreme events. Their inclusion in studies of riverbank erosion and channel morphodynamics can improve the interpretation of temporal changes in process intensity and help to explain variations associated with climate variability. Such knowledge may also support strategic planning and the development of measures aimed at reducing the impacts of channel instability on environment and local communities.

Keywords: riverbank erosion, variability, climate change, Serbia

Acknowledgement

This work was supported by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia (Contract number: 451-03-34/2026-03/200091).

References

- Aktar, N. (2013). Impact of Climate Change on Riverbank Erosion. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, 36-42.
- Langović, M., Popović, S., Dragičević, S., Stojanović, Ž. & Manić, E. (2024). Assessment of the Economic Consequences of Riverbank Erosion: The Case of the South Morava River, Serbia. *Water Economics and Policy*. 2450003. DOI: 10.1142/S2382624X24500036.
- Dragičević, S., Živković, N., Roksandić, M., Luković, J., Kostadinov, S. (2015). Recent state, intensity and consequences of riverbank degradation of Kolubara River on the territory of the Obrenovac Municipality. Belgrade: University of Belgrade, Faculty of Geography, 1-266.

[<https://doi.org/10.69646/aob260925>]

[Poster]

Changes in Temperature and Precipitation Regimes in the Šumadija Region, 1961–2024

Radoslav Ranković^{1*}, Slađana Popović¹

¹ Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia

*Correspondence: rankovicradoslav3@gmail.com

Abstract: Climate change is a major focus of contemporary research due to its effects on temperature and precipitation regimes. This study assesses changes in temperature and precipitation regimes in the Šumadija Region, Serbia, over the 1961–2024 period. Climatological data from three synoptic stations (Belgrade, Smederevska Palanka, and Kragujevac) were analyzed using the Mann–Kendall and Pettitt tests, while climatic aridity was assessed using the Pinna Combinative Index. The results reveal statistically significant increasing trends in mean annual and monthly air temperatures at all three stations. The Pettitt test identified 1998 as a change point in the temperature series. In contrast, no statistically significant trend was detected in mean annual precipitation. Despite the observed intra-annual redistribution of precipitation and increasing climatic aridity, all three stations remained classified as humid according to the Pinna Combinative Index. Continuous monitoring is essential for understanding regional climate dynamics and assessing the impacts of climate change.

Keywords: temperature regime, precipitation regime, Šumadija Region.

Introduction

Climate change has the greatest impact on the two most important climatic elements: air temperature and precipitation. Variations in temperature and precipitation regimes are evident at the global, regional, and local levels, making them one of the key scientific issues of today and the subject of numerous studies. These changes significantly affect natural and socio-economic processes worldwide and therefore need to be continuously monitored. Accordingly, the aim of this paper is to examine changes in temperature and precipitation regimes in the Šumadija Region over the period 1961–2024.

Studies conducted in Serbia and across Southeastern Europe indicate an unequivocal upward trend in air temperatures, both in terms of mean annual and mean monthly values. Some authors have examined variations in air temperature (Milovanović et al., 2022), identifying considerable regional differences. Climate change is also associated with variations in precipitation amounts and precipitation regimes, as well as with the increasingly frequent occurrence of extreme precipitation events. This is also evident in Central and Southeastern Europe (Zeder & Fischer, 2020). Changes in precipitation regimes affect the occurrence of droughts, increased climatic aridity, and other natural hazards, such as floods and landslides. However, most studies conducted in Serbia have focused on the analysis of extreme precipitation events and their trends (Tošić et al., 2025; Bezdan et al., 2024; Malinović-Milićević et al., 2018).

The Šumadija Region is located in the central part of Serbia. It is characterized by specific morphological features and tectonomorphogenesis, which are clearly reflected in its climatic characteristics. The region is broadly open towards the Pannonian Plain to the north, while towards the south it gradually transitions into the mountainous terrain of the Dinarides. Consequently, Šumadija is exposed to the influence of different air masses. The northern part of the region, known as Low Šumadija, is characterized by a continental climate, whereas the southern part, known as High

Šumadija, exhibits the characteristics of a temperate warm and humid climate (temperate-continental climate).

Methods and data

For the purposes of this study, three synoptic stations were selected. The Belgrade station (132 m) is subject to the specific influence of the urban heat island, which has significantly affected the temperature regime since the mid-20th century. The Smederevska Palanka station (121 m) records climatic conditions in the lower part of Šumadija, while the Kragujevac station (181 m) represents the conditions of a basin surrounded by mountains (Rudnik, Gledić Mountains, and Kotlenik) in the higher part of Šumadija. To determine trends in temperature and precipitation regimes, climatological data for the period 1961–2024 were used (Meteorological yearbooks, Republic Hydrometeorological Service of Serbia). Changes in mean annual air temperature and mean annual precipitation were analyzed using several statistical methods: the Mann–Kendall test, the Pettitt test, and the Pinna Combinative Index.

The Mann–Kendall test is a non-parametric statistical method widely used to identify monotonic trends in time series data. It determines whether a statistically significant upward or downward trend is present over time and is suitable for datasets containing outliers or non-linear trends, as it does not require a specific probability distribution. The null hypothesis (H_0) assumes that the observations are independent and identically distributed, indicating no significant trend, whereas the alternative hypothesis (H_1) assumes the presence of a statistically significant upward or downward trend (Sen, 1968). In this study, the Mann–Kendall test was applied to assess trends in temperature and precipitation regimes during the 1961–2024 period. The Pettitt test is a non-parametric method widely used in climatology to detect abrupt changes or change points in time series. It does not require assumptions regarding the probability distribution of the data. The null hypothesis (H_0) assumes that the data are homogeneous throughout the observation period, with no significant

change in the location parameter, whereas the alternative hypothesis (H_1) assumes a statistically significant shift in the location parameter at a specific point in time (Pettitt, 1979). In this study, the Pettitt test was used to identify change points in temperature and precipitation regimes during the 1961–2024 period.

The Pinna Combinative Index (I_p) was also used in this study. This index builds upon the De Martonne Aridity Index by introducing an additional term for regions experiencing a pronounced dry season (Andrade & Corte-Real, 2016). The index is calculated using the following equation:

$$I_p = \frac{1}{2} \cdot \left(\frac{P}{T + 10} + \frac{12P'_d}{T'_d + 10} \right)$$

where P and T represent the annual mean values of precipitation and air temperature, respectively, while P'_d and T'_d represent the mean values of precipitation and air temperature, respectively, in the driest month. According to the Pinna Combinative Index, values below 10 indicate a dry climate, values between 10 and 20 indicate a semi-dry climate, and values above 20 indicate a humid climate.

Results and discussion

The Mann–Kendall test for the Belgrade station indicates a pronounced upward trend in mean monthly and annual air temperatures. The most pronounced warming is observed during the summer months, with August showing the highest rate of increase, approximately 0.76 °C per decade. November is the only month in which no significant increasing trend is detected. The Pettitt test also identified a statistically significant change point in the mean annual air temperature at the Belgrade station. Since the obtained p -value ($p < 0.001$) is lower than the significance level of 0.05, the null hypothesis is rejected, indicating a statistically significant change in the time series. The Pettitt test identified 1998 as the change point.

During the period 1961–1997, the mean annual air temperature was 11.9 °C, whereas during the period 1998–2024, it increased to 13.6 °C. The Mann–Kendall test for the Smederevska Palanka station also indicates a significant increase in mean monthly and annual air temperatures over the analyzed period. The highest rates of increase were observed during the summer months, particularly in August, whereas the mean monthly temperatures in May and November did not exhibit a significant upward trend. Similar to the results obtained for Belgrade, the Pettitt test identified a statistically significant change point in the temperature series, with a p-value below 0.001. The identified change point is 1998, indicating a pronounced structural shift in the mean annual air temperature. During the period 1961–1997, the mean annual air temperature was 11.8 °C, increasing to 12.4 °C during the period 1998–2024.

Similar changes in the thermal regime were observed at the Kragujevac station. A clear upward trend in mean annual air temperature was identified. In the higher, southern part of Šumadija, in addition to the increase in mean monthly temperatures in July and August, a pronounced increase in mean January temperatures was also observed. The Pettitt test produced results similar to those obtained for the other two stations, identifying 1998 as the change point between the two periods. The mean annual air temperature was 11.0 °C during the period 1961–1997, increasing to 12.5 °C during the period 1998–2024.

In contrast to the temperature regime, which clearly exhibits an increasing trend at all three stations, the applied statistical methods did not reveal a statistically significant increasing or decreasing trend in mean annual precipitation. Furthermore, according to the Pinna Combinative Index, all three selected stations are characterized by a humid climate based on the mean values for the 1961–2024 period. The lowest index value was recorded at Kragujevac station (32), while the values for Belgrade and Smederevska Palanka stations were both 34.

Conclusions

The results obtained using the applied methods indicate that all three selected stations in the Šumadija Region are characterized by a humid climate. A statistically highly significant increasing trend in mean annual and monthly air temperatures was identified in Šumadija ($p < 0.01$), contributing to an increase in potential evapotranspiration. Trends in annual precipitation totals are generally not statistically significant, but they indicate intra-annual redistribution, with moisture deficits occurring during the winter and late summer periods. The Pettitt homogeneity test clearly identifies 1998 as the change point in the temperature series for the study region. This year divides the observed time series into two climatically heterogeneous sub-periods: the first, 1961–1997, which was cooler, and the more recent period, 1998–2024, which was warmer.

References

- Andrade, C. and Corte-Real, J. (2016) 'Aridity conditions in the Iberian Peninsula during the XX century', *International Journal of Environmental Science*, 1, pp. 52–58.
- Bezdan, J., Bezdan, A., Blagojević, B., Antić, S., Greksa, A., Milić, D. and Lipovac, A. (2024) 'Impact of Climate Change on Extreme Rainfall Events and Pluvial Flooding Risk in the Vojvodina Region (North Serbia)', *Atmosphere*, 15(4), 488.
- Malinović-Miličević, S., Mihailović, D., Radovanović, M. and Drešković, N. (2018) 'Extreme Precipitation Indices in Vojvodina Region (Serbia)', *Journal of the Geographical Institute "Jovan Cvijić" SASA*, 68(1), pp. 1–15.
- Milovanović, B., Stanojević, G. and Radovanović, M. (2022) 'Climate of Serbia', in Manić, E., Nikitović, V. and Djurović, P. (eds) *The Geography of Serbia: Nature, People, Economy*. Cham: Springer, pp. 57–68.

Pettitt, A.N. (1979) 'A non-parametric approach to the change-point problem', *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 28, pp. 126–135.

Republic Hydrometeorological Service of Serbia (RHMSS) (1961–2024) '*Meteorological Yearbooks – Climatological Data*'. Belgrade: Republic Hydrometeorological Service of Serbia.

Sen, P.K. (1968) 'Estimates of the regression coefficient based on Kendall's tau', *Journal of the American Statistical Association*, 63(324), pp. 1379–1389.

Tošić, I., Alves da Silva, A.S., Filipović, L., Tošić, M., Lazić, I., Putniković, S., Stosic,

T. and Djurdjević, V. (2025) 'Trends of Extreme Precipitation Events in Serbia Under the Global Warming', *Atmosphere*, 16, 436.

Zeder, J. and Fischer, E.M. (2020) 'Observed extreme precipitation trends and scaling in Central Europe', *Weather and Climate Extremes*, 29, 100266.

[<https://doi.org/10.69646/aob260926>]

[Poster]

New dataset for planet formation chemistry and modeling

Vladimir A. Srećković^{1*}, Nicolina Pop², Veljko Vujčić³,
Magdalena D. Christova⁴, Felix Iacob⁵, Milica Langović¹, Aleksandra Kolarski¹

¹Institute of Physics Belgrade, University of Belgrade, Pregrevica 118,
Belgrade, Republic of Serbia

²Politehnica University of Timisoara, Timisoara, Romania

³Astronomical Observatory, Volgina 7, 11060 Belgrade 38, Serbia

⁴Department of Applied Physics, TU Sofia, Bulgaria

⁵West University of Timișoara, Vasile Părvan Boulevard, 300233, Romania

Correspondence: vlada@ipb.ac.rs

Abstract: Astrophysical models are fundamental tools for interpreting the molecular composition and evolution of interstellar and circumstellar environments, as well as for constraining their physical conditions. The accuracy and predictive capability of these models strongly depend on the availability and reliability of molecular databases and reaction-rate coefficients obtained from both theoretical calculations and laboratory measurements. In this context, comprehensive and accessible atomic and molecular datasets, including resources such as VAMDC, are essential for developing and improving models of molecular processes relevant to star and planet formation. Particular attention is required for molecular ions, whose radiative and collisional processes can significantly influence the chemical balance and abundance of species in astrophysical environments. Among these processes, dissociative recombination plays an important role in determining the survival and destruction pathways of molecular ions. In this work, we calculate, assess, and analyze cross sections and rate coefficients for selected molecular ions, with particular emphasis on hydrogen- and helium-containing systems. The calculations are performed for a

range of model parameters to investigate their dependence on the physical conditions and to provide reliable data for incorporation into astrochemical and astrophysical modeling databases.

Keywords: data, modeling, planets

Acknowledgement

This work was funded by the Institute of Physics Belgrade, University of Belgrade, through a grant by the Ministry of Science, Technological Development, and Innovations of the Republic of Serbia. Authors would like to acknowledge the support received from the Science Fund of the Republic of Serbia, #GRANT 6821, Atoms and (bio)molecules-dynamics and collisional processes on short time scale - ATMOLCOL. and COST Action CA22133 - The birth of solar systems (PLANETS).

[<https://doi.org/10.69646/aob260927>]

[Poster]

Perceptions of Air Pollution in Belgrade: A Survey Analysis

Ana Nešić^{1*}, Katarina Damjanović¹, Sara Tadić¹, Teodora Jovičić¹,
Aleksa Muljajić¹

¹Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000
Belgrade, Serbia; students

*Correspondence: nesicaaa7@gmail.com

Abstract: This paper addresses the issue of air pollution in Belgrade through an analysis of citizen's perceptions of air quality, based on an online survey. The aim of the study is to highlight the importance of air quality in urban environments and, based on the results obtained in the survey, to determine the extent to which the citizens of Belgrade are aware of this environmental issue and the potential impact of air quality on public health. In addition to the survey research, the methodology also included an analysis of relevant air – quality data obtained from the competent national agency. A comparative analysis was conducted using data for the summer and winter periods for the pollutants PM_{2.5}, PM₁₀, NO₂ and CO. The results indicate higher concentrations of particulate pollutants during the winter period, demonstrating a correspondence between the analytical findings and the perceptions of the majority of respondents, who identified winter as the period of more intense air pollution. The findings are also consistent with respondent's views regarding the main sources of air pollution.

Keywords: air pollution, Belgrade, public opinion, environment, health impact

Introduction

Air pollution represents one of the major environmental and health problems of modern society, particularly in large urban areas. With the development of industry, population growth and the increasing use of motor vehicles, air quality in cities has become an increasingly important environmental issue (Ram Mahala, 2024; Tsekeri et al., 2025). Belgrade, as the capital and largest city of Serbia, faces a pronounced air-quality problem that may negatively affect human health and the environment. In recent years, air pollution in Belgrade has attracted increasing attention from the public, media and experts (RERI, 2024).

The purpose of this research was therefore to examine the main sources and causes of air pollution and its consequences for the population and the environment. A survey among citizens was conducted to examine their perception on the degree of air pollution, their familiarity with the problem, perceived health effects and habits or measures that may contribute to reducing pollution. The survey results provide a better understanding of public awareness of this problem and of the extent to which citizens are prepared to contribute to environmental protection. In addition, measured air-quality data were used to compare public perceptions with the observed situation during selected winter and summer conditions in Belgrade.

Methods and data

The research paper concerning air pollution in Belgrade was conducted using an online survey and an assessment of public opinion. A total of 263 participants took part in the research. The aim of the survey was to determine how familiar citizens are with the problem of air pollution, what the causes of air pollution are whether air pollution causes difficulties, what an individual could do to address this problem, and what opinions and attitudes people hold regarding possible solutions.

To determine the observed state of air quality in Belgrade, verified data collected at automatic monitoring stations of the Serbian Environmental Protection Agency for the calendar year 2024 were used (SEPA, 2024). The extended analysis focused on the Novi Beograd monitoring station and compared one selected winter day (31 January 2024) with one selected summer day (19 July 2024). The parameters considered were: NO₂, PM_{2.5} and PM₁₀, and CO. This simple seasonal comparison was used to obtain a clearer picture of differences between winter and summer pollution and to examine whether measured conditions corresponded with the perceptions expressed in the survey.

Results and discussion

According to the data obtained from the first two survey questions, the majority of respondents were female (70.7%), while the largest proportion of respondents was in the 18–25 age group (62%). Regarding familiarity with the problem of air pollution, the average response was 3.94, indicating that citizens are, to a considerable extent, aware of this problem. The largest proportion of responses was five stars, selected by 35.7% of respondents, indicating that they considered themselves fully familiar with the problem of air pollution. Respondents were also asked to indicate their opinion of how polluted they considered the air in Belgrade to be. The average response was 4.57, leading to the conclusion that, in the respondents' opinion, the air is highly polluted. The largest proportion selected five stars (66.5%). The analysis of responses to this question leads to the conclusion that air pollution is perceived as a major environmental problem and challenge, affecting many human activities and, in particular, human health.

What do you think are the main causes of pollution?

263 responses

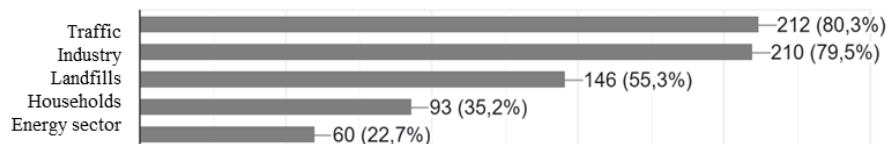


Figure 1. What do you think are the main causes of pollution?

Regarding the main sources of pollution, a large proportion of respondents identified traffic and industry. The next most frequently identified source was illegal waste disposal sites. In addition, a significant number of respondents identified households as major sources of air pollution, particularly emissions released into the atmosphere during winter. The energy sector ranked fifth, with 22.7%. Pollution on an annual basis was also considered. The response receiving the most votes was the middle of the heating season, December–February, with 60.2%. This response led to the conclusion that air pollution is perceived as most severe during winter, partly because meteorological conditions can facilitate the accumulation and prolonged retention of polluted air. The “whole year” option was selected by 28% of respondents.

Regarding difficulties experienced under conditions of increased concentrations of various pollutants, the most frequently reported difficulties were respiratory problems, selected by 43.9% of respondents. Respondents also reported headaches, dizziness and migraines, as well as throat irritation, fatigue, discomfort while breathing and watery eyes.

Respondents were also given the opportunity to select which measures an individual could undertake. The majority considered tree planting to be the most beneficial measure, with 78.8%. Proper waste disposal using designated containers received 66.7%, while 62.9% of respondents identified the use of renewable energy as a good starting point for improving air quality. Furthermore, 50.4% of respondents considered a shift towards public transport and

reduction in the use of private vehicles to be measures that could contribute to environmental protection.

When asked whether they considered the data on air pollution in Belgrade to be sufficiently transparent, the largest proportion of respondents (68.9%) stated that the data were not sufficiently transparent. 84.5% of respondents stated that public awareness of air pollution was not sufficiently developed. When air pollution is particularly severe, the largest number of respondents stated that they do not change their daily routines depending on pollution levels. A total of 57.2% of respondents agreed with the statement that they do not change anything, while 26% selected either staying indoors or monitoring pollution trends through applications.

Table 1. Air-quality data for the Novi Beograd monitoring station in 2024

Monitoring station		Pollutants			
Novi Beograd	Selected dates	PM _{2.5} (µg/m ³)	PM ₁₀ (µg/m ³)	NO ₂ (µg/m ³)	CO – max 8h (mg/m ³)
	31.01.2024.	70.3	92.7	60.9	1.1
	19.07.2024.	13	23.4	20	0.1
	Daily limit values	15 µg/m ³	50 µg/m ³	85 µg/m ³	10 mg/m ³

The second part included results of monitoring station Novi Beograd. During the winter period on January 31st 2024, PM_{2.5} concentrations reached 70.3 µg/m³, while during the summer period, on July 19th 2024, the concentration was 13 µg/m³. Regarding PM₁₀ particles, the concentration on January 31st 2024 reached 92.7 µg/m³, whereas on July 19th 2024 it was 23.4 µg/m³. The NO₂ concentration was 60.9 µg/m³ during the winter period and 20 µg/m³ during the summer period, while CO values were 1.1 mg/m³ and 0.1 mg/m³, respectively. Based on the presented data, it can be concluded that harmful concentrations of pollutants in the air are higher during the winter than during the summer period. The causes of increased pollutant concentrations include fossil-fuel combustion, traffic emissions,

industrial activity and the burning of coal and wood for household heating during winter. The measured data therefore show a correspondence with the perceptions of the majority of respondents, who identified winter as the period of more intense air pollution.

Conclusions

The research showed that citizens are largely aware of the problem of air pollution and of its possible consequences for the population and the environment. Most respondents considered the air in Belgrade to be highly polluted, particularly during winter, which coincides with the heating season. The analysis of selected air-quality data also showed substantially higher PM_{2.5} and PM₁₀ concentrations on the winter day than on the summer day, providing measured support for this perception.

Traffic and industry were recognized as the dominant pollution sources, while households, illegal waste disposal and the energy sector were also frequently identified. The findings further indicate that solving the problem of air pollution requires joint action by public institutions, experts and citizens. Education about environmental protection and the development of ecological awareness, particularly among young people, are important for long-term improvement. Although completely eliminating air pollution is difficult, appropriate measures and responsible behavior can contribute to better air quality and living conditions in Belgrade.

References

- Ram Mahala, K. (2024). The impact of air pollution on living things and Environment: A review of the current Evidence. *World Journal of Advanced Research and Reviews*. 3208-3217.
- RERI (2024). Analiza stanja kvaliteta vazduha u Republici Srbiji za 2024. godinu. Available from <https://reri.org.rs/wp-content/uploads/2025/06/Analiza-stanja-kvaliteta-vazduha-u-Republici-Srbiji-za-2024.-godinu.pdf>

Sepa (2024). Indeks kvaliteta vazduha. Available from <https://vazduh.sepa.gov.rs/#>

Tsekeri, E., Lilli, A., Lazaridis, M. and Kolokotsa, D. (2025). Air pollution in the urban built environment: A comprehensive evaluation. *Atmospheric Pollution Research*, 17.

[<https://doi.org/10.69646/aob260928>]

[Poster]

Discharge Trend Dynamics of the Nišava River (Serbia)

Stefan Manojlović¹

¹Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000
Belgrade, Serbia

*Correspondence: stefan.manojlovic@gef.bg.ac.rs

Abstract: This study analyses long-term discharge trends of the Nišava River at the Dimitrovgrad and Niš hydrological stations for the period 1954–2025. Mean annual, seasonal and monthly discharge series were examined using the Mann-Kendall test and Sen's slope estimator, while the Pettitt test was applied to identify abrupt changes in mean annual discharge. Statistically significant decreasing trends in mean annual discharge were detected at both stations, with a stronger absolute decline at Niš. A common change point was identified between 1981 and 1982, after which mean discharge values were lower, while no significant trends were found within the two subperiods. Seasonal and monthly analyses showed that the most pronounced decreases were concentrated in spring and early summer, particularly at Niš.

Keywords: Nišava River, river discharge, discharge trends

Introduction

Climate change affects the hydrological cycle through changes in temperature, precipitation patterns and evapotranspiration, which can consequently alter river discharge regimes and water availability (Langović, 2019). Previous studies in Serbia have predominantly identified decreasing discharge trends. Kovačević-Majkić and Urošev (2014), analysing 94 hydrological stations during 1961–2010, found

decreasing annual trends at 68% of stations, with the largest number of statistically significant decreases occurring in the South Morava River basin. On the Nišava River, a statistically significant decreasing trend was identified at the Niš profile, while the decrease at the Dimitrovgrad profile was not statistically significant. Langović (2019), analysing 20 stations in the South Morava River basin for the period 1968–2017, similarly found decreasing mean annual discharge trends at 85% of stations, with decreasing trends observed at both Dimitrovgrad and Niš, although neither was statistically significant. The aim of this study is to analyse long-term discharge trends of the Nišava River at the Dimitrovgrad and Niš hydrological stations during the period 1954–2025. Mean annual, seasonal and monthly discharge trends are analysed in order to determine their direction, magnitude and statistical significance. The extended observation period, which includes the most recent data up to 2025, enables an updated assessment of discharge dynamics and comparison with previously identified trends.

Methods and data

Discharge data for the hydrological stations Dimitrovgrad and Niš on the Nišava River were obtained from the Hydrological Yearbooks of the Republic Hydrometeorological Service of Serbia (RHMSS) for 1954–2025 (RHMSS, 1954–2025). Monthly and mean annual discharge (Q) series were analysed. Seasonal mean discharge values were calculated for winter (DJF), spring (MAM), summer (JJA) and autumn (SON). For winter, seasonal mean discharge was calculated using December of the reference year and January and February of the following year.

Temporal trends were assessed using the non-parametric Mann-Kendall test (Kendall, 1975), while the magnitude of change was quantified using Sen's slope estimator and expressed in $\text{m}^3/\text{s}/\text{year}$ (Ali et al., 2019). Statistical significance was evaluated at the 0.05 level.

The Pettitt test (Pettitt, 1979) was applied to the mean annual discharge series in order to identify potential abrupt changes. The detected change point was then used to divide the series into two subperiods, 1954–1981 and 1982–2025, for which Mann-Kendall and Sen's slope analyses were repeated.

Results and discussion

The analysis of mean annual discharge for the period 1954–2025 revealed statistically significant decreasing trends at both hydrological stations. At the Dimitrovgrad station, the Mann-Kendall test indicated a significant negative trend ($p=0.0113$), with a Sen's slope of $-0.0133 \text{ m}^3/\text{s}/\text{year}$. A considerably stronger negative trend was identified at the Niš station ($p=0.00024$), where the Sen's slope amounted to $-0.2179 \text{ m}^3/\text{s}/\text{year}$.

The Pettitt test identified the same statistically significant change point at both hydrological stations, occurring between 1981 and 1982. Mean annual discharge decreased from $2.28 \text{ m}^3/\text{s}$ to $1.75 \text{ m}^3/\text{s}$ at the Dimitrovgrad profile and from $34.80 \text{ m}^3/\text{s}$ to $24.45 \text{ m}^3/\text{s}$ at the Niš profile between the 1954–1981 and 1982–2025 subperiods. However, no statistically significant Mann-Kendall trends were detected within either subperiod, suggesting that the long-term decrease is primarily associated with a shift in discharge levels around the beginning of the 1980s rather than a continuous decline throughout the observation period.

Seasonal trend analysis showed predominantly decreasing discharge tendencies at both profiles during the observed period. At the Dimitrovgrad profile, a statistically significant negative trend was identified only in spring ($p=0.0412$), with a Sen's slope of $-0.0213 \text{ m}^3/\text{s}/\text{year}$. At the Niš profile, the spring decrease was also observed, albeit at a higher level of statistical significance ($p=0.0026$), with a Sen's slope of $-0.4297 \text{ m}^3/\text{s}/\text{year}$. A statistically significant decreasing trend was additionally identified in summer ($p=0.0366$; Sen's slope = $-0.1008 \text{ m}^3/\text{s}/\text{year}$), while the remaining seasonal trends were not statistically significant. Results of the Mann-Kendall test and Sen's

slope estimator for mean annual and seasonal discharge are presented in Table 1.

Table 1. Mann-Kendall test and Sen's slope results for mean annual and seasonal discharge

Series	Period	Dimitrovgrad		Niš	
		p-value	Sen's slope (m ³ /s/year)	p-value	Sen's slope (m ³ /s/year)
Annual	1954–2025	0.0113	-0.0133	0.00024	-0.2179
	1954–1981	0.9056	-0.0051	0.2859	-0.1717
	1982–2025	0.8476	0.0017	0.6273	0.0592
Winter	1954–2025	0.1818	-0.0094	0.0934	-0.1632
Spring	1954–2025	0.0412	-0.0213	0.0026	-0.4297
Summer	1954–2025	0.1119	-0.0063	0.0366	-0.1008
Autumn	1954–2025	0.1210	-0.0041	0.5962	-0.0192

Note: Bold p-values indicate statistically significant trends ($p < 0.05$)

Monthly trend analysis identified statistically significant negative trends in May, July and September at the Dimitrovgrad profile, and from March to July at the Niš profile. The largest monthly decrease was observed in May at both profiles, particularly at Niš, where the Sen's slope amounted to $-0.4753 \text{ m}^3/\text{s}/\text{year}$ ($p=0.00005$). Detailed results of the Mann-Kendall test and Sen's slope estimator for individual months are presented in Table 2. Overall, the monthly analysis indicates that the most pronounced decreases are concentrated mainly in spring and early summer, particularly at the downstream Niš profile.

The obtained results are generally consistent with previous research on the Nišava River. Đokić (2015), analysing the period 1961–2009, identified a change point in mean annual discharge at the Niš profile in 1981, with average discharge decreasing from $33.90 \text{ m}^3/\text{s}$ to $23.58 \text{ m}^3/\text{s}$. The present analysis, extended to 2025, identified practically the same change point and comparable mean discharge values. Monthly results also largely confirmed previously identified decreases in spring and early summer, with April additionally showing a significant decrease in the present analysis.

Table 2. Mann-Kendall test and Sen's slope results for monthly discharge during 1954–2025

Month	Dimitrovgrad		Niš	
	p-value	Sen's slope (m ³ /s/year)	p-value	Sen's slope (m ³ /s/year)
January	0.2205	-0.0062	0.2355	-0.0948
February	0.0536	-0.0153	0.1395	-0.1656
March	0.0907	-0.0200	0.0375	-0.3372
April	0.3506	-0.0139	0.0349	-0.3631
May	0.0089	-0.0222	0.00005	-0.4753
June	0.0542	-0.0125	0.0191	-0.1909
July	0.0324	-0.0063	0.0436	-0.0979
August	0.0759	-0.0039	0.2317	-0.0332
September	0.0061	-0.0055	0.0768	-0.0393
October	0.1054	-0.0035	0.8382	-0.0070
November	0.0626	-0.0061	0.2079	-0.0587
December	0.3096	-0.0052	0.1719	-0.1000

Note: Bold p-values indicate statistically significant trends ($p < 0.05$)

The observed changes likely reflect both natural and anthropogenic influences. Langović (2019) reported a correlation of about 0.65 between annual precipitation and discharge at Niš, while Đokić (2015) also identified increasing temperatures and decreasing precipitation in the basin. Anthropogenic impacts are relatively limited near Dimitrovgrad but become more pronounced downstream, where water use for the Niš water-supply system was estimated to reduce discharge at the Niš profile by about 11% on average, with a greater relative impact during low-flow periods. Therefore, the common change point identified at both stations may indicate a broader basin-scale hydrological shift, while water use may additionally affect discharge at the Niš profile.

Conclusions

The analysis of discharge trends on the Nišava River during 1954–2025 revealed statistically significant long-term decreases in mean annual discharge at both Dimitrovgrad and Niš. The common change point identified around 1981/1982 indicates that the long-term

reduction is largely associated with a shift in discharge levels rather than a continuous decline throughout the entire observation period. Seasonal and monthly analyses showed that the most pronounced decreases are concentrated in spring and early summer, particularly at the Niš station. The results are generally consistent with previous studies of the Nišava River and confirm the persistence of previously identified hydrological changes. Natural factors, including changes in temperature and precipitation, together with anthropogenic water use, may contribute to the observed discharge dynamics, especially in the downstream part of the basin.

References

- Ali, R., Kuriqi, A., Abubaker, S. and Kisi, O. (2019) Long-term trends and seasonality detection of the observed flow in Yangtze River using Mann-Kendall and Sen's innovative trend method, *Water*, 11(9), p. 1855. <https://doi.org/10.3390/w11091855>
- Đokić, M.M. (2015). *Nišava – potamology study*. Doctoral dissertation, University of Niš, Faculty of Sciences and Mathematics, Department of Geography.
- Kendall, M.G. (1975). *Rank Correlation Methods*, 4th ed. London: Charles Griffin.
- Kovačević-Majkić, J. and Urošev, M. (2014). Trends of mean annual and seasonal discharges of rivers in Serbia. *Journal of the Geographical Institute "Jovan Cvijić" SASA*, 64(2), pp. 143–160. <https://doi.org/10.2298/IJGI1402143K>
- Langović, M. (2019). Annual and seasonal variations of river discharges in the South Morava River Basin (Republic of Serbia). In: *Proceedings of the International Scientific Symposium New Trends in Geography*. 3–4 October 2019, Ohrid, pp. 27–36. <https://doi.org/10.37658/procgeo1927I>
- Pettitt, A.N. (1979). A non-parametric approach to the change-point problem. *Journal of the Royal Statistical Society: Series C (Applied Statistics)*, 28(2), pp. 126–135.

Republic Hydrometeorological Service of Serbia (RHMSS) (1954–2025). *Hydrological Yearbooks*. Available online: <https://www.hidmet.gov.rs> (accessed on 17 August 2026).

[<https://doi.org/10.69646/aob260929>]

[Poster]

New Molecular Datasets for Modeling Astrophysically Relevant Radiative Processes

Vladimir A. Srećković^{1*}, Violeta Petrović², Hristina Delibašić Marković²

¹Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade, Serbia

²University of Kragujevac, Faculty of Science, Radoja Domanovića 12, 34000 Kragujevac, Serbia

Correspondence: vlada@ipb.ac.rs

Abstract: This work investigates radiative processes, with particular emphasis on photodissociation, in asymmetric molecular systems containing hydrogen and silicon. The study provides a comprehensive set of calculated molecular data, including the characterization of relevant electronic states and the determination of photodissociation cross sections over a broad range of EUV and UV photon wavelengths. Temperature-dependent photodissociation rate coefficients are derived by combining the calculated cross sections with appropriate radiation fields. To facilitate their implementation in numerical models, analytical fitting expressions are developed for both the photodissociation cross sections and the corresponding spectral rate coefficients. The resulting data provide useful input for photochemical and plasma-chemistry models and can contribute to a more accurate description of molecular processes in laboratory plasmas and astrophysical environments.

Keywords: data, modeling, molecules

Acknowledgement

Authors would like to acknowledge the support received from the Science Fund of the Republic of Serbia, #GRANT 6821, Atoms and (bio)molecules-dynamics and collisional processes on short time scale - ATMOLCOL. Also, we acknowledge support of the Institute of Physics Belgrade, University of Belgrade, through a grant by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia. Our appreciation also goes to the Serbian Ministry of Education, Science and Technological Development (Agreement No. 451-03-136/2025-03/ 200122).

[<https://doi.org/10.69646/aob260930>]

[Poster]

Earthquakes and Population Vulnerability: Evidence from Southern Europe

Luka Đurović^{1*}

¹ Faculty of Geography, University in Belgrade, Studentski trg 3/3, 11000 Belgrade, Serbia, PhD student

*Correspondence: luka.djurovicgeos@gmail.com

Abstract: Natural disasters and their consequences are a widely studied topic that has gained increasing importance in the academic community in recent years. Earthquakes are among the disasters that have a particularly strong impact on the environment and society, with potentially fatal outcomes. This paper is based on the EM-DAT database on the total population affected by earthquakes and includes an overview of the potential for expanding research on this topic in the future. Between 1990 and 2025, more than 900,000 people were affected by earthquakes in Southern Europe. However, a more detailed analysis indicates territorial differences in the impact of earthquakes in this region. This initial finding opens the door to numerous topics that can be explored in the future, such as the conditions for prevention and evacuation of the endangered population, as well as their daily activities and living conditions in hazardous environments across different countries in this region. Ultimately, in-depth insights regarding this issue can inform disaster risk reduction strategies and foster cross-border cooperation in the region.

Keywords: earthquakes, population vulnerability, Southern Europe

2nd International Meeting on Building Bridges Between Climate Science and Society Through a Transdisciplinary Network

21-25 September 2026, Belgrade, Serbia & virtual

Program Schedule

2nd International Meeting on Building Bridges Between Climate Science and Society Through a Transdisciplinary Network														
in organization of Scientific Society Isaac Newton Belgrade, Institute of Physics Belgrade, University of Belgrade, and Astronomical Observatory Belgrade														
Monday (day 1) September 21, 2026			Tuesday (day 2) September 22, 2026			Wednesday (day 3) September 23, 2026			Thursday (day 4) September 24, 2026			Friday (day 5) September 25, 2026		
Start	End	Session	Start	End	Session	Start	End	Session	Start	End	Workshop	Start	End	Session
14:00	15:00	Registration	10:30	11:30	Lectures	10:00	11:30	Lectures	10:00	11:00	Off-site Student and ECR Meet and Greet	08:30	10:00	Lectures
15:00	15:30	Opening ceremony	11:30	12:00	Coffee break	11:30	12:00	Coffee break	11:00	11:30	Coffee break	10:00	10:30	Coffee break
Lectures			12:00	13:30	Networking Session	12:00	13:30	Lectures	11:30	13:00	Interactive Field Workshop	10:30	11:30	Organizing committee meeting
15:30	16:00	Keynote speaker 1	13:30	15:00	Lunch break	13:30	15:00	Lunch break	16:00	18:00	Educational tour	11:30	12:00	Closing ceremony
16:00	16:30	Keynote speaker 2	15:00	16:00	Lectures	15:00	16:30	Poster presentation 2						
16:30	18:00	Welcome cocktail	16:00	17:30	Poster presentation 1									
			20:00	22:00	Conference dinner									

CONFERENCE PROGRAM

Monday, September 21, 2026

Time		Session
Start	End	
14:00	15:00	Registration
15:00	15:30	Opening ceremony <i>Organizing Committee</i>
15:30	16:00	Keynote Speaker: <u>Milan Dimitrijević</u> Affiliation: Astronomical Observatory, Belgrade, Serbia Lecture Title: Molecular data for climate science Author/s: Milan S. Dimitrijević, Vladimir A. Srećković, Veljko Vujčić
16:00	16:30	Keynote Speaker: <u>Aleksandar Valjarević</u> Affiliation: Faculty of Geography, University of Belgrade Lecture Title: Linking Climate Stress, Land-Use Change and River-System Sustainability: A GIS-Based Ecological Equilibrium Index for Serbia Author/s: Aleksandar Valjarević
16:30	18:00	Welcome cocktail

Tuesday, September 22, 2026

Time		Session
Start	End	
10:30	11:00	Speaker: <u>Igor Leščešen</u> Affiliation: Institute of Hydrology, Slovak Academy of Sciences Lecture Title: Hydrological Droughts in the Carpathian Basin: From Historical Evidence to Future Risk under CMIP6 Climate Scenarios Author/s: Igor Leščešen
11:00	11:30	Speaker: <u>Aleksandra Nina</u> Affiliation: Institute of Physics Belgrade, University of Belgrade Lecture Title: VLF amplitude noise reductions as earthquake precursors: statistical analysis Author/s: Aleksandra Nina, Pier Francesco Biagi, Giovanni Nico, Hans U. Eichelberger, Mohammed Y. Boudjada
11:30	12:00	Coffee break Speaker: <u>Filip Kostić</u> Lecture Title: Navigating the Editorial Process in International Journals
12:00	13:30	Speaker: <u>Zoran Mijić</u> Affiliation: Institute of Physics Belgrade, University of Belgrade Lecture Title: Review of the COST networking activities - modifications of the rules and introduction of new opportunities for ITC participants Author/s: Zoran Mijić, Bratislav Marinković
13:30	15:00	Lunch break Speaker: <u>Lamia Abu El Maati</u> Affiliation: Department of Physics, College of Science, Princess Nourah Bint Abdulrahman University
15:00	15:30	Lecture Title: On the atomic structure of the seven-times ionized sulfur ion S VIII Author/s: Lamia Abu El Maati, Nabil Ben Nessib, Milan S. Dimitrijević
15:30	16:00	Speaker: <u>Milica Langović</u> Affiliation: Institute of Physics Belgrade, University of Belgrade Lecture Title: Air Pollution as a Driver of Population Mobility: Empirical Evidence and Underlying Mechanisms Author/s: Milica Langović, Zoran Vidović

Poster presentations

Author/s: Peter Bednár, Aleksandra Nina, Aleksandra Kolarski, Peter Butka, Martin Sarnovský, Vladimir Srećković, Ognyan Kounchev

Title: Ionospheric Disturbances & Machine Learning: VLF Signal Variation Detection and Perspectives

Author/s: Luka Đurović

Title: Spatial Distribution of Floods and Earthquakes in Southern Europe: An Analysis at the NUTS 3 Regional Level (1990–2025)

Author/s: Vladimir A. Srećković, Violeta Petrović, Hristina Delibašić Marković

Title: New Molecular Datasets for Modeling Astrophysically Relevant Radiative Processes

16:00

17:30

Author/s: Nikola Veselinović, Mihailo Savić, Darije Maričić, Mila Ranitović, Dejan Joković, Radomir Banjanac, Žarko Medić

Title: Recent Solar Activity: A Preliminary Analysis Based on Cosmic-Ray Observations

Author/s: Marko Langović, Nenad Živković, Slavoljub Dragičević

Title: Assessment of Long-Term River Discharge Variability and Precipitation Coherence: The South Morava River, Serbia

Author/s: Vladimir A. Srećković, Nicolina Pop, Veljko Vujčić, Magdalena D. Christova, Felix Iacob, Milica Langović, Aleksandra Kolarski

Title: New dataset for planet formation chemistry and modeling

Author/s: Zoran Vidović

Title: Statistical Methods for Analysing Environmentally Induced Migration Intentions

20:00

22:00

Conference dinner

Wednesday, September 23, 2026

Time		Session
Start	End	
10:00	10:30	Speaker: <u>Dejan Vasović</u> Affiliation: Faculty of Occupational Safety, University of Niš Lecture Title: Tracing the Path from Soil Erosion to Drinking Water Risk: A Modelling Framework for Water Safety Planning Author/s: Dejan Vasović, Ana Stojanović, Sladjan Hristov
10:30	11:00	Speaker: <u>Marija Ljakoska</u> Affiliation: Saints Cyril and Methodius University, Faculty of Natural Sciences and Mathematics, Institute of Geography Lecture Title: Perceptions and Attitudes Toward Temperature Trends and Climate Change in North Macedonia: A Survey-Based Analysis Author/s: Filip Naumovski, Marija Ljakoska, Emilija Manevska, Arse Kuzmanoski, Anita Todorova
11:00	11:30	Speaker: <u>Tijana Radosavljević</u> Affiliation: Faculty of Geography, University of Belgrade Lecture Title: Trend of air temperature at the meteorological station Vranje during the period 1949-2024 Author/s: Tijana Radosavljević, Sanja Manojlović
11:30	12:00	Coffee break
12:00	12:30	Speaker: <u>Natalija Nikolić</u> Affiliation: University of Novi Sad, Faculty of Sciences, Department of Geography, Tourism and Hotel Management Lecture Title: Heat Waves in Rural Regions of Serbia: Who is the Most Vulnerable? Author/s: Natalija Nikolić, Milica Vasić
12:30	13:00	Speaker: <u>Jelena Svetozarević</u> Affiliation: Climate, Atmosphere and Water Research Institute at Bulgarian Academy of Sciences (CAWRI-BAS) Lecture Title: Continentality Indices as a Common Language for Climate and Society: A Precipitation Seasonality Case Study of Babušnica (Serbia) and Sofia (Bulgaria), 1961–2020 Author/s: Jelena Svetozarević
13:00	13:30	Speaker: <u>Veljko Vujčić</u> Affiliation: Astronomical Observatory, Belgrade, Serbia Lecture Title: Semantic Orchestration for Time-Domain Astronomy Author/s: Veljko Vujčić

13:30	15:00	Lunch break Poster presentations Author/s: <u>Radoslav Ranković, Slađana Popović</u> Title: Changes in Temperature and Precipitation Regimes in the Šumadija Region, 1961–2024 Author/s: <u>Ana Nešić, Katarina Damjanović, Sara Tadić, Teodora Jovičić, Aleksa Muljajić</u> Title: Perceptions of Air Pollution in Belgrade: A Survey Analysis Author/s: <u>Milica Langović, Vladimir A. Srećković, Georgi Boyadjiev, Ognyan Kounchev, Hans U. Eichelberger, Georgi Simeonov</u> Title: The Astro-Geo Interface: Prospects and Directions for Future Research
15:00	16:30	Author/s: <u>Emilija Manevska, Arse Kuzmanoski, Filip Naumovski, Anita Todorova, Marija Ljakoska</u> Title: Correlation between air temperature and air pollution in the city of Skopje Author/s: <u>Vladimir Srećković, Georgi Boyadjiev, Ognyan Kounchev, Aleksandra Kolarski, Milica Langović, Aleksandra Nina, Zoran Mijić, Hans U. Eichelberger</u> Title: Big Data Analysis in Astrophysics and Physics: A Multidisciplinary Approach Author/s: <u>Stefan Manojlović</u> Title: Discharge Trend Dynamics of the Nišava River (Serbia) Author/s: <u>Marko Langović</u> Title: Process-based insights into lateral channel migration and riverbank erosion under climate variability Author/s: <u>Luka Đurović</u> Title: Earthquakes and Population Vulnerability: Evidence from Southern Europe

Thursday, September 24, 2026

Time		Workshop
Start	End	
		Bridging the gap: Climate, environment and society An interactive <i>Student Workshop</i> on Transdisciplinary Approaches
10:00	11:00	Off-site Student and ECR Meet and Greet
11:00	11:30	Coffee break
11:30	13:00	Interactive Field Workshop
16:00	18:00	Educational tour

Friday, September 25, 2026

Time		Session
Start	End	
		Speaker: <u>Ivana Đorđević</u> Affiliation: Faculty of Geography, University of Belgrade Lecture Title: Is climate sufficiently present in the classroom? An analysis of content and outcomes on climate change in Geography curricula in primary schools Author/s: Ivana Đorđević, Mina Marković, Slavoljub Jovanović
08:30	09:00	
		Speaker: <u>Filip Krstić</u> Affiliation: Faculty of Geography, University of Belgrade Lecture Title: Climate Aridity Changes and Their Impact on Agricultural Production - Case Study: South Serbia Author/s: Filip Krstić, Mirjana Gajić
09:00	09:30	
		Speaker: <u>Marko Langović</u> Affiliation: Institute of Physics Belgrade, University of Belgrade Lecture Title: Bridging Climate Science and Society: Summary Insights and Future Perspectives Author/s: Marko Langović
09:30	10:00	
10:00	10:30	Coffee break
10:30	11:30	<i>Organizing committee meeting</i>
11:30	12:00	Closing ceremony

AUTHORS' INDEX

- Abu El Maati, L. 23
Banjanac, R. 92
Bednár, P. 78
Ben Nessib, N. 23
Biagi, P.F. 55
Boudjada, M.Y. 55
Boyadjiev, G. 80, 90
Butka, P. 78
Christova, M.D. 102
Damnjanović, K. 104
Delibašić Marković, H. 118
Dimitrijević, M.S. 12, 23
Đorđević, I. 65
Dragičević, S. 82
Đurović, L. 88, 120
Eichelberger, H. 55, 80, 90
Gajić, M. 58
Hristov, S. 24
Iacob, F. 102
Joković, D. 92
Jovanović, S. 65
Jovičić, T. 104
Kolarski, A. 78, 90, 102
Kounchev, O. 78, 80, 90
Krstić, F. 58
Kuzmanoski, A. 21, 76
Langović, M. 53, 80, 90, 102
Langović, M. 82, 93
Leščesen, I. 31
Ljakoska, M. 21, 76
Manevska, E. 21, 76
Manojlović, S. 42
Manojlović, S. 111
Maričić, D. 92
Marinković, B. 51
Marković, M. 65
Medić, Ž. 92
Mijić, Z. 51, 90
Muljajić, A. 104
Naumovski, F. 21, 76
Nešić, A. 104
Nico, G. 55
Nikolić, N. 40
Nina, A. 55, 78, 90
Petrović, V. 118
Pop, N. 102
Popović, S. 95
Radosavljević, T. 42
Ranitović, M. 92
Ranković, R. 95
Sarnovský, M. 78
Savić, M. 92
Simeonov, G. 80
Srećković, V.A. 12, 78, 80, 90, 102, 118
Stojanović, A. 24
Svetozarević, J. 37
Tadić, S. 104
Todorova, A. 21, 76
Valjarević, A. 14
Vasić, M. 40
Vasović, D. 24
Veselinović, N. 92
Vidović, Z. 53, 75
Vujčić, V. 12, 73, 102
Živković, N. 82

CIP - Каталогизacija у публикацији
Народна библиотека Србије, Београд

551.583:6(048)

INTERNATIONAL Meeting on Building Bridges Between Climate Science and Society Through a Transdisciplinary Network (2 ; 2026 ; Beograd)

Book of abstracts and contributed papers / 2nd International Meeting on Building Bridges Between Climate Science and Society Through a Transdisciplinary Network, 21-25 September 2026, Belgrade, Serbia & virtual ; [organizers Scientific Society Isaac Newton Belgrade [and] University of Belgrade, Institute of Physics [and] Astronomical Observatory Belgrade] ; edited by Milica Langović ... [et al.]. - Belgrade : Scientific Society Isaac Newton, 2026 (Beograd : Skripta Internacional). - 129 str. : graf. prikazi, tabele ; 24 cm

ISBN 978-86-906850-3-5

a) Климатске промене -- Мултидисциплинарни приступ -- Апстракти

COBISS.SR-ID 201305865