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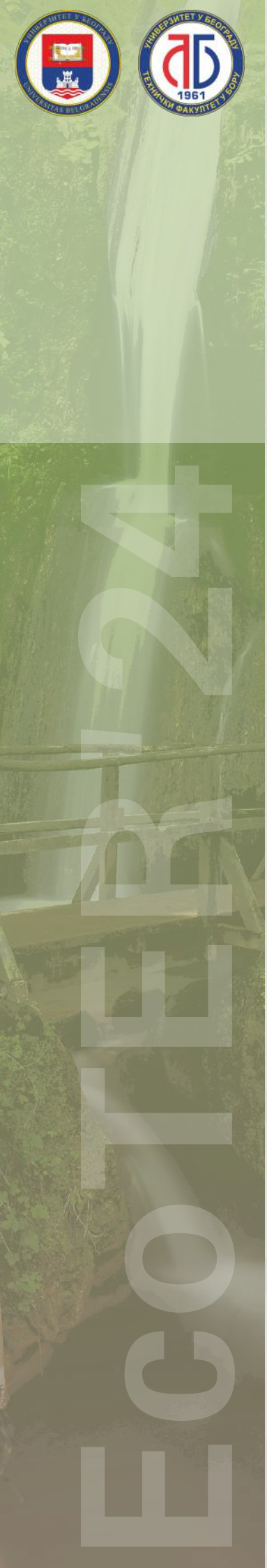

31st International conference

Ecological Truth & Environmental Research

Editor
Prof. Dr Snežana Šerbula

PROCEEDINGS

Hotel Sunce, Sokobanja, Serbia
18–21 June 2024

PROCEEDINGS

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PREFACE

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 focuses on showing the latest research findings and innovations in the field of ecology, environmental protection and sustainable development. The conference will be held in Sokobanja (Serbia) in hotel Sunce in the period of 18–21 June 2024.

The aim of the conference is to connect the experts in various fields in order to transform attitudes and behaviors in everyday practices, as well as in the industry and economy sector which is essential for achieving the desired changes that our society must undergo.

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology; the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica; the University of Zagreb, Faculty of Metallurgy – Sisak; the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Society of Young Researchers – Bor.

These Proceedings encompass 119 papers from the authors coming from the universities, research institutes and industries in 15 countries: Brazil, Norway, USA, Spain, Austria, Libya, Italy, Israel, Slovenia, Croatia, Romania, Bulgaria, Montenegro, Bosnia and Herzegovina, North Macedonia, and Serbia. It is a great honor and pleasure to cordially wish a warm welcome to all the participants of the conference.

As a part of this year's conference, the 6th Student Section – EcoTERS'24 will be held. We appreciate the contribution of the students and their mentors who have also participated in the conference and hope that students will continue to explore and to be curious, since education is a never-ending process, and knowledge is continuously growing.

The organization of the EcoTER'24 conference has been financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The support of the Donors and their willingness and ability to cooperate has been of great importance for the success of the EcoTER'24 conference. The organizing committee would like to extend their appreciation and gratitude to the Platinum donors of the conference – Serbia ZiJin Copper doo Bor and HBIS SERBIA, to the Gold donor of the conference – Elixir Group, as well as to the Silver donor of the conference – Serbian Chamber of Engineers.

We would like to express our sincere appreciation to all the authors who have contributed to the Proceedings. We would also like to express our gratitude to the members of the scientific, organizing and honorary committees, reviewers, speakers, chairpersons and all the conference participants for their support of the EcoTER'24. Sincere thanks go to all the people who have contributed to the successful organization of the EcoTER'24.

Prof. Snežana Šerbula,

President of the scientific and organizing committee

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GLOBAL WARMING – TREND ANALYSIS IN THE REPUBLIC OF SERBIA

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Abstract

Global warming, as part of general climate change, has certainly become an undeniable fact. An increasingly small part of the scientific and professional population denies this dramatic change in one of the most important parameters of the Earth's climate system, as well as the causes that encourage this process. The trend of temperature increase, as expected, varies to a certain extent in different parts of our planet. In this paper, an appropriate analysis of the temperature increase in the territory of the Republic of Serbia from the middle of the last century until today was performed. At the same time, as part of the analysis, a comparison was made with the global change. In the end, the city of Kragujevac was taken as a representative of the change in climate parameters in the Republic of Serbia and an analysis of the changes in the mentioned period was carried out. All the presented data indicate that climate change, and primarily Global Warming, is accelerating. This process already has serious, and with intensification can have catastrophic consequences for the living world on the planet, including humans.

Keywords: climate change, Republic of Serbia, global warming, changes in climate parameters.

INTRODUCTION

The Earth's climate system is a complex dynamic system made up of five most important components, namely the atmosphere, hydrosphere, cryosphere, lithosphere and biosphere. Part of the climate system, in addition to these components, are also the constant reactions between them. The Earth's climate, as a product of the functioning of the climate system, has experienced a number of smaller or larger, as well as faster and slower changes in the history of the planet. All these changes, until recently, were always under the influence of natural mechanisms and certain internal and external factors. If we define the influence of man on the climate, since the middle of the twentieth century, as "unnatural" (although man himself is a part of nature, his influence and activities over the last few decades have exceeded the defense mechanisms of the climate system), then this is the first period in the history of the Earth in which "unnatural" changes. The greenhouse effect is one of the natural climate regulatory mechanisms available to the Earth's atmosphere. This mechanism raises the average temperature on our planet by more than thirty degrees Celsius (compared to a hypothetical state without an atmosphere) and allows life conditions to exist in the largest part of it.

The sudden increase in the number of human population, accelerated industrialization, way of life and high energy needs cause huge emissions of gases with the greenhouse effect. These emissions exceed the natural abilities of the system to absorb them and keep them within acceptable limits. By comparing the corresponding diagrams, a clear coincidence is observed between the increase in CO_2 concentration and the increase in global temperature [1]. Global warming is the most significant part of overall climate change. The trend of temperature increase varies in intensity in different regions of the Earth, but the change is certainly of a general, planetary character.

TREND OF CHANGE IN AVERAGE ANNUAL TEMPERATURES IN THE WORLD

An increase in global temperatures has been observed since the middle of the 20th century, but in recent decades, and especially in the last one, there has been an acceleration of changes. Figure 1 shows the increase in average annual temperatures by world region in the last two decades (2002–2011 and 2012–2021) measured above the land surface of the planet [2]. It is observed that the regions of Asia, Africa and North America record temperature increases at the level of the global average. Below that average, with a slightly slower rate of warming so far, are the regions of Australia and Latin America. The most significant increase in average annual temperatures is recorded on the European continent, and it is almost 50% higher than the world average, and twice as high as the Australian region.

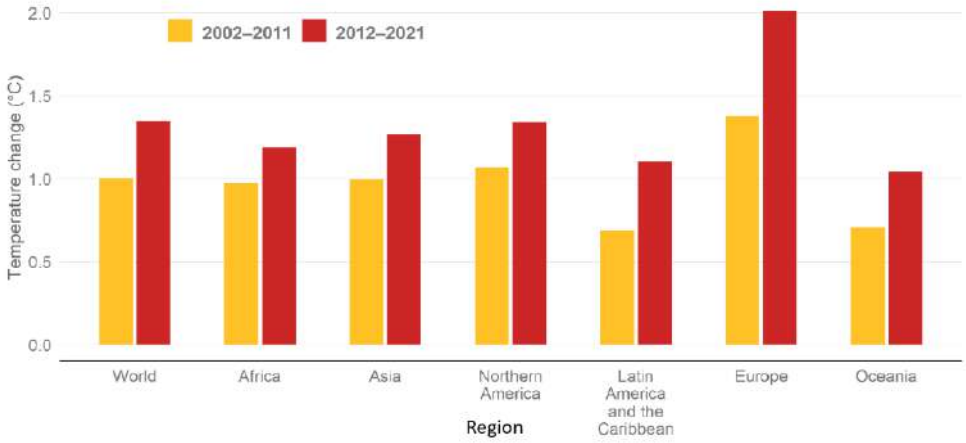

Figure 1 *Temperature changes by world regions in the last two decades (Source: FAO, 2022. FAOSTAT: Temperature change)*

Figure 2 shows a diagram that compares the annual deviations of Tan values (average annual air temperatures), i.e. the values of GLaOATA (Global Land and Ocean Average Temperature Anomalies) and GLATA (Global Land Average Temperature Anomalies) for the period from 1850–2023. and in relation to the reference period 1901–2000 [3,8]. Due to the significantly higher inertia and heat capacity, it can be seen that the curve of global air temperature change over land including sea and ocean surfaces (GLaOATA) is significantly more stable (with a smaller amplitude of variation, as well as a smaller overall change) than

the curve that corresponds only to land areas (GLATA). In colder periods, especially in the first half century of the observed time range, the change in air temperatures over the land had a larger negative deviation compared to the global one. Similarly, in the warm period, and especially in the last few decades, the difference between the increase in air temperatures over the land compared to the ocean surfaces is rapidly increasing. A huge problem and great potential for future warming of the planet is the enormous accumulated heat in the ocean waters, especially in the surface layer (up to 700 meters deep). That new accumulated energy (period 1950–2023) is estimated (for a depth of up to 2000 meters) at about 500 Zettajoules (1 Zettajoules = 1 billion trillion joules) [4].

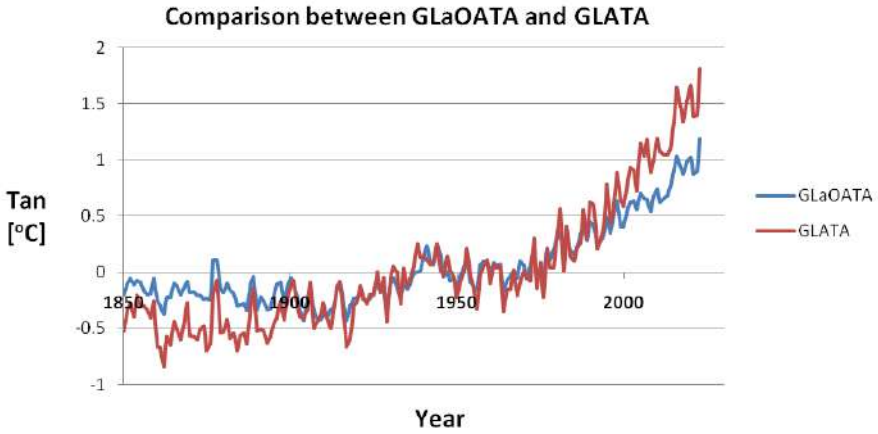

Figure 2 *Comparison between values GLaOATA and GLATA*

Figure 3 shows the deviations of annual mean air temperatures, namely NHLoOATA (Northern Hemisphere Land and Ocean Average Temperature Anomalies), NHLATA (Northern Hemisphere Land Average Temperature Anomalies) and EATA (European Average Temperature Anomalies). Values for NHLoOATA and NHLATA [3,8] are given for the interval 1850–2023, and the period 1901–2000 was taken as reference. For the size of EATA, data are presented for the period 1910–2023, with the reference period 1910–2000 (due to lack of earlier data).

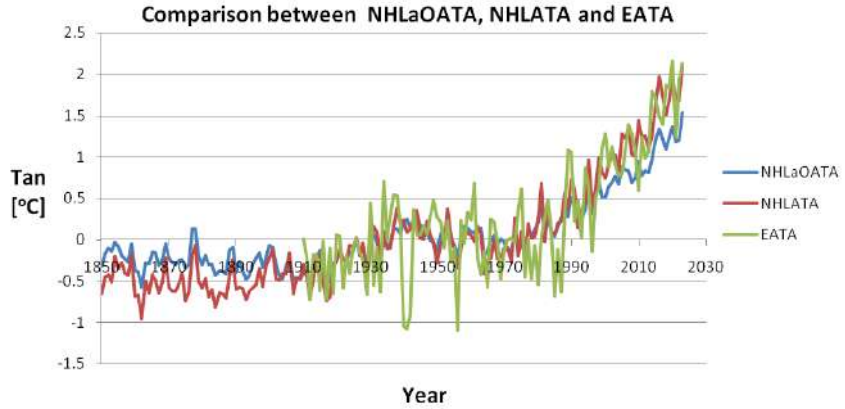

Figure 3 *Comparison between values NHLaOATA, NHLATA and EATA*

The relationship between the magnitudes of NHLoOATA and NHLATA roughly corresponds to the relationship already described for Figure 2 (magnitudes of GLaOATA and GLATA) When it comes to the magnitude of EATA, a significantly greater instability of mean temperatures can be observed. The reason for this probably lies in the fact that the land area is significantly smaller. And based on this diagram, it can be concluded that, especially in the last few decades, the European continent is warming at a faster rate than the rest of the Northern Hemisphere.

CHANGES IN AVERAGE ANNUAL TEMPERATURES IN THE REPUBLIC OF SERBIA

The Republic of Serbia is located in the southeastern part of the European continent, which, according to decades of observations, has one of the highest rates of increase in average annual temperatures. The Republic of Serbia is landlocked and, until recently, most of it had a typical moderate-continental climate. The diagram shown in Figure 4 shows the deviations of the average annual temperature (Taa) calculated for the territory of the entire republic in the period 1951–2023 from the norm for the reference period 1991–2020 [5,6,7]. As in the previous diagrams, a significant increase in the displayed size can be observed here, especially in the last two decades. In the last year (2023), a deviation of 1.5^{o}C was reached, noting that already in the reference period (1991–2020) there was an increase compared to the previous one (1961–1990) by about 1^{o}C. This means that the total increase in average annual temperatures for the territory of the Republic of Serbia in recent years has already reached an extremely serious 2.5^{o}C. As part of the further analysis, the city of Kragujevac was chosen, which is located in the central part of the Republic of Serbia and is located at an average altitude of about 180 meters.

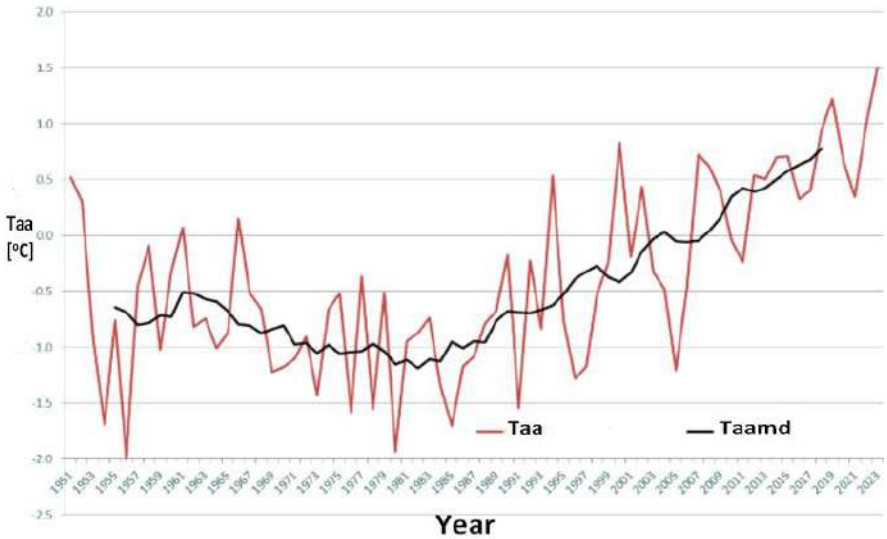

Figure 4 *Deviation of the average annual temperature in Serbia in the period 1951–2023 (compared to the reference period 1991-2020; Taamd – average anomaly for the decade)*

The diagram in Figure 5 shows the average annual temperatures for the city of Kragujevac (Tak) in the period 1961–2023. Here too, a very similar increase can be observed from an

average of about 11°C during the period 1961–1990, to a value of 13.6°C in 2023. Perhaps an even more obvious presentation of the trend is given in Figure 6, where the values of average annual temperatures by decade (Tadk) are given, noting that the last interval refers to the last three-year period (2021–2023). To the possible remark that the three-year period is relatively short to reflect the character of the trend for the whole decade, comes the pessimistic statement that the average value of the future period of the rest of that decade (until 2030) will increase that value even more.

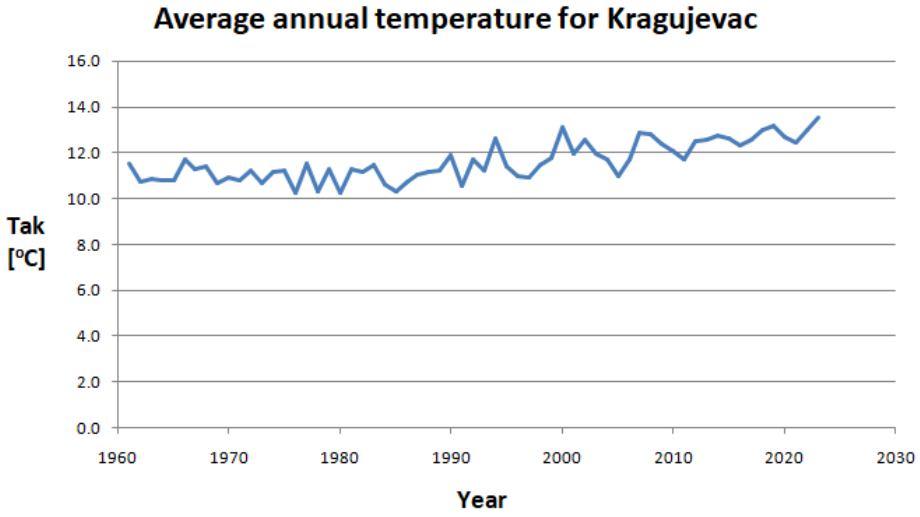

Figure 5 *Average annual temperatures for Kragujevac (in the period 1961–2023)*

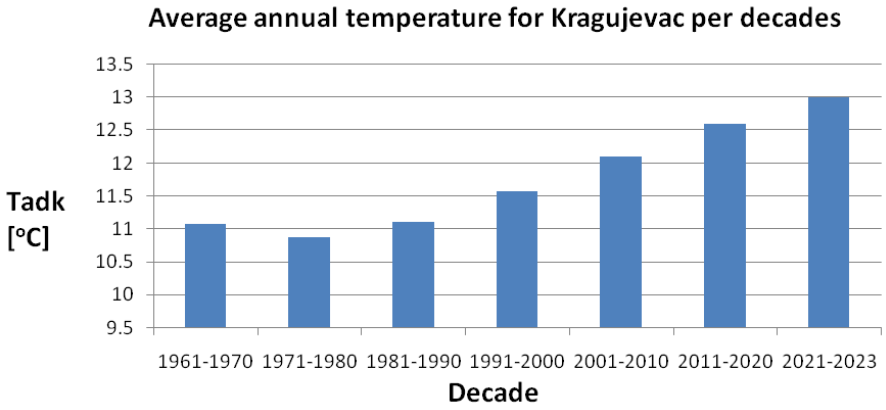

Figure 6 *Average annual temperatures for Kragujevac per decades (in the period 1961–2023)*

Table 1 shows the values of average summer temperatures (Tasm) for three summer months (June, July and August) by decades of the observed period. The summer part of the year, both for the territory of the Republic of Serbia and for the city of Kragujevac, showed the highest degree of increase in average temperatures compared to other parts of the year [9].

Table 1 *Average temperatures for Kragujevac in the summer months (June, July and August) by decades*

Decade	1961–1970	1971–1980	1981–1990	1991–2000	2001–2010	2011–2020	2021–2023
Tasm	20.2	19.6	20.1	21.4	21.9	22.3	22.9

CONCLUSION

The climate system of the Earth as a product of its functioning forms the climate of our planet. Excessive human influence causes various disturbances in the functioning of that system, and thus leads to climate changes. Global warming is the main representative of climate change and currently the most pronounced change in one of the climate parameters. The increase in average temperatures is not uniform in all parts of the planet and in this sense there are significant differences by region. Land areas are warming faster than ocean surfaces, but the oceans have been storing enormous amounts of additional heat during recent decades that will certainly affect the future temperature regime of the planet. The European continent shows one of the fastest rates of warming, and this fact is especially true for its southeastern part, to which the Republic of Serbia belongs. The presented values of the increase in average annual temperatures for the Republic of Serbia and the city of Kragujevac indicate that in relation to the reference period 1961–1990, there was a warming of 2 to 2.5 degrees Celsius in these areas. This level of increase in average annual temperatures to an extremely serious extent can affect many aspects of human life, as well as the entire flora and fauna. What is particularly worrying is that the trend of warming the planet, and especially some of its parts, is accelerating.

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