

**Building bridges between climate science and  
society through a transdisciplinary network**

September 10-14, 2024, Kopaonik Mt, Serbia

**BOOK OF ABSTRACTS AND  
CONTRIBUTED PAPERS**

Edited by Vladimir A. Srećković, Aleksandra Kolarski,  
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Belgrade, 2024



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## **SCIENTIFIC RATIONALE**

Establishing connections between climate and society necessitates a cooperative strategy that utilizes a transdisciplinary network of experts. The primary objective of this conference is to bring together researchers and professionals from various disciplines to tackle the intricate issues that arise at the crossroads of climate and society. The event will consist of three main sessions: "Transdisciplinary Approaches to Climate and Social Challenges," "Geophysics and Astrophysics: Understanding Climate Interactions," and "Climate and Transport: Shaping a Sustainable Environment." Participants will examine innovative methods and exchange ideas on the successful integration of knowledge across various fields. By engaging in plenary sessions and targeted mini-projects, participants will collaborate to create extensive resolutions that tackle urgent environmental concerns. This will lead to the production of joint publications in important scientific journals.

### **Venue**

Kopaonik Mt. (Educational and Scientific base Blaževo), Serbia

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# *Plenary Lectures*

## **Nobel prizes for physics obtained for astronomical discoveries in XXI century**

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**Abstract:** Nobel prizes for physics in 2002, 2006, 2011, 2013, 2015, 2017. and 2019, obtained for astronomically important discoveries are discussed.

**Keywords:** Nobel prizes, astronomy, physics

The Nobel Prize in Physics is the most prestigious international prize in this scientific discipline, which is awarded annually by the Swedish Royal Academy of Sciences, as a sign of recognition for great scientific achievements. It was established by the Swedish scientist and inventor Alfred Nobel in 1895, and was awarded for the first time in 1901. The award ceremony is held in Stockholm on December 10, the day of Nobel's death.

Nobel did not provide a prize for astronomers, but a large number of astronomical discoveries were awarded in the field of physics. A series of such awards in the XXI century began in 2002, when one half was awarded to Riccardo Giacconi (1931-2018), the father of X-ray astronomy, and the other was shared by Raymond Davis (1914-2006) and Masatoshi Koshiba (1926-2020), the father of neutrino astronomy.

Herbert Friedman was the first, in 1949, to register extraterrestrial X radiation from the solar corona using

instruments on the V2 rocket, and on June 18, 1962, using an Aerobee rocket that flew for 6 minutes, Giacconi discovered the first cosmic X-ray source, X-1 in Scorpio, in the center of our galaxy, and the uniform X radiation of the sky background. Giacconi also initiated the first satellite dedicated to X - astronomy, Uhuru, launched on December 12, 1970, which increased the number of known cosmic sources of X radiation from 40 to 400. He also constructed the first X-ray telescope, launched on July 23, 1999 on the cosmic X observatory *Chandra*. Giacconi's work and his discoveries led to the birth of X-ray astronomy.

Bruno Pontecorvo proposed that high-energy neutrinos from space be hunted based on their reaction with the chlorine atom, which produces an electron and a radioactive isotope of argon. Davis tried that in the early 60s, placing a tank with 615 tons of tetrachlorethylene in an abandoned mine, where 20 argon atoms were supposed to be formed in a month. Hunting for them was considered impossible by many, saying that it is like trying to find twenty specific grains of sand in the Sahara. By 1994, Davis separated about 2,000 argon atoms created by the reaction with neutrinos from the solar core, which was the first detection of cosmic neutrinos, which marked the birth of neutrino astronomy. That was only a third of the number predicted by theory. This is how the puzzle of solar neutrinos arose, which has occupied astronomers for years.

Masatoshi Koshiba constructed a much larger neutrino detector or neutrino telescope and named it *Kamiokande*. It was a huge tank filled with water in which the rare reaction of neutrinos with the nuclei of atoms released electrons and photons, surrounded by photomultipliers that registered them. Unlike Davis's device, *Kamiokande* was able to register both the time and direction of neutrino arrival. With it, Koshiba in 1987, out of a flood of  $10^{16}$  neutrinos from the supernova of that year,

managed to capture twelve. Koshiba and Davis received the Nobel Prize in 2002 for the detection of cosmic neutrinos.

The Nobel Prize crowned the astronomical discovery and in 2006. It was obtained by John C. Mather (1946) and George Smoot (1945), who discovered in the background radiation irregularities important for the formation of the first galaxies and that it is the same as black body radiation. Background radiation, which comes from the background of the entire sky, was predicted by George Gamow in the 1940s as a consequence of the cooling of the universe, which occurred when the temperature dropped to the limit when radiation and matter separated and the first light shone through the previously opaque cosmos. The rest of it, background radiation, was discovered by Arno Penzias and Robert Wilson in 1964, and for that they received the Nobel Prize in 1978. Mather and Smoot made their discovery using the COBE (Cosmic Background Explorer) satellite, launched in 1989 specifically for background radiation research. After such measurements and research, cosmology became a precise science with clear results confirming the Big bang theory.

In 2011, Saul Perlmutter (1959), Brian Schmidt (1967) and Adam Riess (1969) received the Nobel Prize for one of the greatest astronomical discoveries of the late twentieth century, which fundamentally shook the cosmology of the time. Two groups of scientists, who observed very distant supernovae, established in 1989 that about five billion years ago the expansion of the cosmos began to accelerate. This led to the concept of dark energy, responsible for this process and significantly changed views on the ultimate fate of the universe.

Two years later, in 2013, François Englert (1932) and Peter Higgs (1929-2024) were awarded, who, independently of each other, theoretically explained how subatomic particles acquire mass. The prize-winning theory is a central part of the Standard

Model of particle physics, which explains what the universe is made of, so that it also indirectly applies to astronomy.

Higgs and Englert included in the theory a field that permeates the entire cosmos and is now called the Higgs field. In interaction with it, fundamental particles, and consequently the matter built from them, gain mass, without which we and the universe as we know it could not exist. The mediator or messenger of this field is the Higgs boson. In 2012, using the Large Collider at CERN, this particle was discovered, which confirmed their theory, which was awarded the Nobel Prize the very next year, in 2013.

The astronomical discovery was also awarded the Nobel Prize in 2015. The topic was again neutrino astronomy, and the laureates were Kajita Takaaki (1959) and Arthur McDonald (1943), who, continuing the work of Koshiba and Davis, successfully solved the puzzle of the small number of solar neutrinos. After *Kamiokande*, Koshiba built an even more perfect neutrino telescope, the *Superkamiokande*, on which Takaaki worked. There are three types of neutrinos: electron, muon and tau. Using Koshiba's *Superkamiokande*, Takaaki discovered neutrino oscillations during which one species transforms into another. This is only possible if they have mass. In the interior of the Sun, electron neutrinos are produced, which were measured by Davis and Koshiba. Unlike *Supercamiocande*, which could only capture electron neutrinos, the new neutrino telescope in Canada was able to register all three types, and a team led by Arthur MacDonald showed that as many electron neutrinos were being produced in the Sun as predicted, but that two-thirds are transformed into muons and tau on the way to Earth, thus solving the puzzle of solar neutrinos.

The 2017 Nobel Prize in Physics was awarded to Rainer Weiss (1932), Barry Barish (1936) and Kip Thorne (1940) for observing gravitational waves. For this purpose, two devices

were constructed in the USA as part of the LIGO project, in Hanford, Washington, and in Livingston, Louisiana. A similar device was made in Italy as part of the VIRGO project. It is interesting that two sure candidates for this Nobel Prize, Ronald Drever (1931-2017), co-founder of the LIGO project and Adalberto Giazotto (1940-2017), the father of the VIRGO device, passed away a few months before the selection of the laureate.

The story of the discovery of gravitational waves begins in the eighties of the XIX century when Maxwell described electrical and magnetic phenomena with a unique theory that required electromagnetic waves to propagate in a vacuum with a constant speed  $c$ . But in classical, Newtonian physics, this is possible only in one coordinate system that is at absolute rest. It was assumed that it is connected to something that fills the entire universe and is called ether.

In order to try to measure the absolute speed of the Earth relative to the assumed ether, Albert Michelson (1852-1931) built the interferometer that bears his name today. Michelson failed to establish any change in the speed of light due to possible motion relative to the ether, which was surprising at the time. The explanation of the results of this experiment was only brought by Albert Einstein and his theory of relativity. For his measurements of the speed of light, and especially for the mentioned experiment and the interferometer, Michelson received the Nobel Prize in 1907.

The two LIGO devices and VIRGO are actually Michelson interferometers but of grandiose proportions and with enormous precision, which made it possible to measure the vibrations of space due to gravitational waves. To make sure that the oscillations are due to these waves, the results obtained on the three devices were compared. The strongest gravitational waves, whose existence was predicted by Albert Einstein a hundred years earlier, are produced by collisions of black holes.

As they begin to approach, they spin faster and faster around their common center of mass until they collide. At the same time, they radiate such waves that deform space-time.

And finally, on September 14, 2015, the LIGO detectors discovered the vibrations of space due to the gravitational waves created by the collision of two black holes of 29 and 36 solar masses, which created a black hole that had 62 solar masses and three solar masses turned into energy of gravitational waves. Thus began the era of gravitational astronomy, which was crowned with the Nobel Prize in 2017.

And 2019 brought another Nobel Prize in physics to astronomers. One half was awarded to James Peebles (1935), for several theoretical results that turned cosmology into a precisely theoretically based scientific discipline, which theoretically and observationally illuminated the history of the universe. Back in 1965, he explained the characteristics of background radiation that behaves like blackbody radiation and predicted that its irregularities are a critical factor in the formation of galaxies. This was confirmed by the analysis of observational data from the *Cobe* satellite, for which John Mather and George Smoot received the 2006 Nobel Prize. In 1970, he calculated and predicted the acoustic oscillations that can be measured and were created together with the irregularities in the background radiation. The *Planck* Space Observatory, which operated from 2009 to 2013, confirmed Peebles' results.

Apart from all this, Peebles showed in 1973 that the halo around our galaxy must have a large amount of non-relativistic cold dark matter for the flat disk to be stable, and in 1984 he returned the so-called cosmological constant, which today actually represents the proportion of dark energy.

The other half of the prize is shared by Swiss astronomers Didier Queloz (1966) and Michel Mayor (1942), who in autumn 1994 discovered the first planet outside the solar system, orbiting

around an ordinary star in the constellation Pegasus (51 Pegasi). They published their discovery in 1995, and it triggered an avalanche of new discoveries, so as of August 8, 2024, we have 5743 confirmed planets in 4286 systems of which 961 have more than one. In addition to the planets around the stars, there are also wandering, rogue planets. To date, extrasolar planets have seen rings, in 2013 the first candidate for a planet's satellite was observed, in 2001 the first exoplanet with an atmosphere was observed, some have tails, like comets, and also, volcanic eruptions have been observed.

An overview of the Nobel prizes for astronomical discoveries, awarded in the XXI century, demonstrates a very extensive, revolutionary and explosive progress of this science, which has greatly changed our view on the development and ultimate fate of the universe and revealed many of its secrets, which helped us to better understand the world around us, its history and our place in it.



## **Milutin Milanković and climate changes - Ice ages secret**

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**Abstract:** The astronomical factors that lead to the periodical formation of the Ice Age and the work of Milutin Milanković on the solution of the secret of their creation were discussed and analyzed.

**Keywords:** Ice ages, Milutin Milanković, History of science

### **Introduction**

The cause of ice ages, a periodic massive cooling in Europe, when, in the greatest cold periods, in many places on the old continent it was like today in Antarctica, was a great scientific puzzle at the beginning of the twentieth century. As early as 1837, German botanist Karl Friedrich Schimper (1803-1867) introduced the term "Ice Age" and assumed that during the Earth's history there were periods of cold climate with formation of glaciers.

Many theories attempting to solve the puzzle of ice ages have been formulated, some of which could not be proven and some were contested by new evidence. Danish-Norwegian geologist Jens Esmark (1763-1839), perhaps the first in 1824, searched in the astronomy the causes of the ice ages, assuming

that on their appearance influence the changes in the Earth's path around the Sun. However, mathematician Joseph Alfons Ademar (1797-1862) published the first true astronomical theory in his book "The Sea Revolution" in 1842, where he denoted the changes of the Earth's path around the Sun as the main cause of ice ages.

Among other pioneers who sought extraterrestrial causes of ice ages, particularly is important Scottish scientist James Croll (1821-1890) who emphasized in a series of works that the periods of glaciation are due to the combination of three astronomical causes, that is, because of the change in the inclination of the Earth's axis, precession and changes in the eccentricity of the Earth's orbit around the Sun. He had only available calculations of Earth orbit changes and the precession in the last 100 000 years, performed by Le Verrier (Urbain Jean Joseph Le Verrier, 1811-1877) and insufficiently accurate data on changes in the inclination of the Earth's axis, so that his considerations indicated that the astronomical causes of the Ice Age had occurred 240,000 years ago and ended before about 80 000 years. This was in contradiction with the data obtained by geologists, showing that the ice age ended about 10,000 years ago. This was the situation with Ice Ages puzzle at the beginning of the twentieth century, when Milutin Milanković started to work on the solution of this problem. The aim of this article is to present its work on it and his solution.



**Figure 1.** Milutin Milanković (Source: [http://arhiva.unilib.rs/unilib/o\\_nama/izlozbe/milankovic\\_virtuelna/ima ges/portret01.jpg](http://arhiva.unilib.rs/unilib/o_nama/izlozbe/milankovic_virtuelna/ima ges/portret01.jpg))

## **The secret of Ice Ages**

Upon his arrival in Belgrade in 1909, Milutin Milanković, begins to work on the investigation of astronomical causes influencing on the formation of an ice age. Unlike Croll, who could only use Le Verrier's calculations of the eccentricity of the Earth's orbit around the Sun and the precession during the last hundred thousand years, now were available Ludwig Pilgrim's

calculations about change not only of eccentricity and precession, but also of the inclination of the Earth's axis for the last one million years.

Let's consider more in detail the significance of these three astronomical causes of climate change on Earth.

**a) The change of the inclination of the Earth's axis between 22,1 and 24,5° with a period of 41,000 years, which leads to changes of the conditions of insolation at a selected point on the surface of our planet.**

To understand why this change is meaningful, imagine what would happen if there were no such inclination. Then throughout the year, at every point on Earth, there would always be the same seasons. In the north there would be eternal winter which would lead to the spread of the ice cover and its penetration to the south. In Europe, a constant Ice Age would dominate. Such an extreme situation should only show how much are important for the climate changes even less than the change of 2.4 degrees.

**(b) The precession (which has several causes), due to which the spring or gamma point (the point in the sky in which the Sun appears at the beginning of the spring) moves along the apparent annual path of the Sun, with a period whose average value in the last 600,000 years, considered by Milanković (when all the causes are taken into account), is 22,000 years, which affects the duration of the seasons.**

On its way around the Sun, the Earth behaves like a top spinning slowly, and its axis describes the surface of a cone. This phenomenon is called precession. It is also influenced by the Moon that causes additional "staggering" of our planet called nutation. How can this affect the amount of heat that comes from the Sun?

If someone asks when our planet is closest to the Sun, how many would answer it is in winter, around January the 3<sup>rd</sup>?

But because of this, it moves faster around the Sun than when it's furthest from our star (around 4 July), so that in Europe the coldest season lasts for seven days and fourteen hours less than the hottest. But due to the precession, it will change and the time will come when it will take longer. Namely, the warmer part of the year in Europe is the time when the Sun apparently moves from spring to autumn equinox. The spring point moves along the apparent path of the Sun, while, in reality, this point moves on the elliptical path of the Earth. If the spring begins when the Earth is closest or farthest from the Sun, the warmer and cooler half of the year have the same length. If it is the closest to the Sun in the middle of winter or summer, the difference in the warmer and cooler half of the year is greatest.

**(b) The change of the eccentricity of the Earth's path around the Sun with a period of 100,000 years, results in a change of the distance from the Sun, which has an influence on the duration of the seasons.**

French astronomer, Urbain Jean Joseph Le Verrier, who became famous for discovering the planet Neptune, showed that the Earth's path cyclically becomes more circular and more elliptical, with eccentricity changing from one to six percent, which also affects the duration of the seasons.

Although the changes due to each of these causes are small, when all three act together, their influence becomes significant.

The problem that should solve Milanković was how to observe the effect of these influences, or what to measure. While Ademar and Croll considered that cold winters should be considered, he accepted the advice of Wladimir Peter Köppen (1846-1940) that cold summers are much more important for the formation of ice ages, as proposed by Joseph John Murphy 1869. Namely, in Siberia, where winter temperature goes up to  $-50^{\circ}\text{C}$  and in the summer up to  $+30^{\circ}\text{C}$  there are no glaciers, since high

summer temperatures cause snow melting. And a large part of Greenland, where winter temperature is about  $-10^{\circ}\text{C}$  and in the summer  $+8^{\circ}\text{C}$ , is under the snow and ice. In addition, Milanković noted that for the spread of glaciers to the south are particularly important weather conditions at great latitudes, in areas where, if there is a cooling down, ice from the north first starts to spread. Therefore, Milanković calculates how, during the last 600,000 years, changes the geographical width of the point that receives from the Sun as much heat as it receives a point at  $65^{\circ}$  latitude today, or to which today's latitude, corresponds the insulation at  $65^{\circ}$  at a time of the past. Note that this is practically rounded the latitude of the polar circle (about  $66,562^{\circ}$ ), passing through the southern part of Greenland, Iceland, Lapland in Scandinavia, the north of Siberia, Alaska and north of the Canada.

Milanković obtained his famous curve of insulation which minima coincide with four assumed Ice Ages during the last 600,000 years (Günz, Mindel, Riss and Würm).

Milanković had his solution of Ice Ages secret dispersed in 28 articles and he realised the need to present it to the scientific community as a unique publication. Because of this he wrote in German his most important work, *Canon of Earth insulation and its influence on the problem of Ice Ages*, where he gave the complete solution of this puzzle.

Milutin Milanković is the most significant Serbian astronomer. As a difference from Nikola Tesla and Mihajlo Pupin, which their discoveries made abroad, Milanković became world famous working in Belgrade.

In honor of his achievements, on XIV Congress of International Astronomical Union (IAU) in Brighton, a crater on the invisible side of the Moon (with coordinates  $+170^{\circ}$   $+77^{\circ}$ ) obtained his name. On XV Congress of IAU in Sidney, his name obtained a crater on Mars (with coordinates  $+147^{\circ}$ ,  $+55^{\circ}$ ), and in 1982, the minor planet 1936 GA, discovered in 1936 by Milorad

Protić and Pero Djurković, obtained the name 1605 Milankovć. This minor planet is on average distance from the Earth of around 450 millions kilometers, while the closest distance is 270 millions kilometers. Its diameter is 32.5 km and the period of its revolution around the Sun is 5.2 years.

Milanković was three times elected for the vice president of the Serbian Academy of Sciences and Arts and was a member of JAZU (Zagreb) and of Academy of natural sciences "Leopoldina" from Hale. European Geophysical Union has from 1993 as an award medal "Milutin Milanković" and NASA put his name in a list of fifteen most important scientists for Geoscience of all times.

# *Invited Lectures*



## **Analysis of possible relationship between earthquakes and Solar flare events during Solar cycle 24**

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**Abstract:** Earthquakes pose a significant threat to the population, causing harm to individuals and also impacting modern infrastructure. Prediction of earthquakes as a subfield of seismology aims to address questions and problems related to forecasting of earthquakes. An area of research that could contribute to this matter is the field of space weather specifically related to the impact of the sun on Earth. This brief communication presents a statistical analysis of occurrences of solar flares and earthquakes during the 24<sup>th</sup> solar cycle. Overall, the findings indicate that it is unlikely to attribute solar flares as a trigger factor for earthquake events; however, the analysis reveals a limited number of intriguing instances that warrant further research.

**Keywords:** space weather, earthquake prediction, statistical analysis.

## **Introduction**

Earthquakes (EQs) are natural occurrences in which seismic waves emitted from a hypocenter propagate outward through surrounding geological structures. During an EQ, a significant amount of energy is released, resulting in potentially catastrophic effects on the population. Consequently, significant endeavors have been undertaken throughout history to assess potential precursors of EQs and to statistically ascertain them. However, predictions of EQs are still with minimal success.

This brief communication presents a statistical analysis of solar flares (SFs) as a potential trigger of EQs on the Balkan peninsula during the 24<sup>th</sup> solar cycle (SC). A multitude of literature studies have proposed correlations between different space weather parameters and EQs. For instance, solar wind (Straset et al. 2014; Cataldi et al. 2016; Marchitelli et al. 2020) and SFs (Novikov et al. 2020; Takla, Samwel, 2023) have been linked to EQs. However, there are also literature findings that raise serious questions about the predictability of EQs as a whole (Rhoades, Evison, 1987; Geller et al. 1997; Kagan, 1997; Hough, 2010). However, conducting a statistical analysis of the strongest (X-class) SFs and EQs registered in the region of the Balkan Peninsula is advantageous in order to verify possible the correlation between SFs and EQs, despite the low likelihood to accurately predict future EQs based on reported SF events.

## **Methods and data**

The EQ data was acquired from the Earthquake Catalog of the United States Geological Survey (<https://earthquake.usgs.gov/earthquakes/search/>). The dataset used in this research was collected for the Balkan peninsula during the 24<sup>th</sup> SC, covering a 11-year time period with EQs of at

least magnitude  $M \geq 4.0$ . Further data processing was conducted in QGIS to eliminate any EQs that are not exclusively located within the Balkan Peninsula.

The algorithm developed for this study was thoroughly presented in Arnaut et al. (2021). Utilized algorithm relies on the use of 5 parameters in total. The parameters used in this study include the time period (measured in days), the number of SFs of a specific class (X- class), the number of EQs, the look-back parameter that defines the duration of days before the EQ that are considered, and the number of iterations conducted by the algorithm.

The algorithm's workflow involves selecting a random sample from a specific time period for two separate groups of data. The first group, referred to as Group A, selects random numbers from a range of 1 to the value of the time period. This group is alternatively referred to as the SF group, as it employs a random distribution of SFs within a given time period. The second group, referred to as Group B, is designated as the EQ group, and values for this group are selected at random from a range of 1 to the value of the time period. This group emulates the random distribution of EQs throughout the specified time period. The initial iteration of the workflow examines each value in group B to determine if there are any values in group A prior to the given value of group B in the length of the look-back parameter. In this way, SFs and EQs are randomly distributed throughout the duration of the analyzed period. Each EQ was assessed to determine if there was a SF in the N days (lookback value) before it. The process was iterated 10,000 times, and the final outcomes were examined. Prior to executing the simulation, we conducted a count of the number of EQs that had an X-class SF(s) for the period of 14, 7, 4, and 1 day(s) before the EQ itself. If the simulated count was greater than the actual count, the results cannot be interpreted as indicating that SFs trigger EQs

in general, as they do not differ from a random chance draw. In order that any correlation between these two phenomena can be considered valid, a higher occurrence rate compared to one obtained in the case of random chance alone is expected.

## **Results and discussion**

The simulation was initially conducted for a look-back value of 14 days, which was an extremely generous duration, as there is currently no evidence to support a two-week effect following an SF. Based on random chance, the simulation predicted that 139 EQs should have an SF in the two weeks prior to the EQ. This value ranged from 102 to 176 out of the 633 EQs in total (16-27%). The actual count of the number of EQs that were affected by SF in the two weeks prior to the current data was 62 (Table 1). This number is insufficient to be considered an actual correlation for all of the instances that were displayed.

The simulation was replicated for a 7-day period prior to the occurrence of the EQ as well. The actual count of EQs that experienced an X-class SF in the week preceding the EQ was 30. However, the analysis indicates that the average count is 74, with a minimum of 46 and a maximum of 101, solely due to random chance. Just like in the previous example, this cannot be considered a correlation, since for establishing the correlation, it would be expected that the number of positive cases is much higher compared to the case of a random distribution.

The simulation was also conducted for a retrospective period of 4 and 1 day(s), yielding results for the 4-day period relatively similar to those previously discussed. However, results obtained for the 1-day period are quite intersecting. In period one day prior to an EQ itself, there were a total of 8 earthquakes with an X-class SF occurring the day before the EQ. The simulated values ranged from a minimum of 1 to a maximum of 23, with an

average value of 11. The simulation was replicated with an increased number of 250,000 iterations, yielding comparable overall results, albeit with a higher maximum value of 27.

**Table 1.** Obtained results of the simulation

<b>Simulation 1</b>	<b>Mean</b>	<b>Min</b>	<b>Max</b>
Look-back parameter [days]	14		/
True number of EQs with a SF before it	62		/
Simulated expected occurrences EQs with SF affected days before	139	102	176
<b>Simulation 2</b>			
Look-back parameter [days]	7		/
True number of EQs with a SF before it	30		/
Simulated expected occurrences EQs with SF affected days before	74	46	101
<b>Simulation 3</b>			
Look-back parameter [days]	4		/
True number of EQs with a SF before it	21		/
Simulated expected occurrences EQs with SF affected days before	43	24	72
<b>Simulation 4</b>			
Look-back parameter [days]	1		/
True number of EQs with a SF before it	8		/
Simulated expected occurrences EQs with SF affected days before	11	1	23

SF- Solar flare; EQ- Earthquake; Number of iterations 10,000; Total number of days in the 24th Solar cycle 4379; Number of X-class SFs in the 24th Solar cycle 77; Total number of EQs in the 24th Solar cycle 633

An in-depth analysis was conducted for cases of these 8 EQs that experienced an X-class SF during the day prior. Among

these 8 cases, two were noteworthy as they were involved in multiple X-class SFs in the days leading up to the EQ. The first EQ analyzed in detail was one that took place on September 25, 2011, and was “associated” with several SFs. Specifically, an X-class SF with a magnitude of X2.14 occurred on September 22, two X-class SFs with magnitudes of X2.74 and X1.02 occurred on September 24, and one X-class SF with a magnitude of X1.07 occurred on the day of the EQ. The second EQ analyzed in detail occurred on May 15th, 2013, and was “associated” with multiple X-class SFs. Specifically, there were two X-class SFs on May 13th, 2013 (X4.11 and X2.51), one on May 14th, 2013 (X4.64), and one on the day of the EQ itself (X1.85). The initial EQ occurred within the borders of Albania (city of Durres), while the subsequent one took place in Montenegro (11 km from Herceg Novi).

Based on the obtained results, SFs cannot serve as a trigger for EQs, mainly due to the complex nature of EQs, which involve numerous parameters that cannot be measured or modeled in an adequate manner. The sample size of 8 earthquakes is insufficient to draw any statistically reliable conclusions about the correlation between analyzed SFs and EQs, specifically the triggering effect of SFs on EQs. However, it remains an intriguing avenue of research that can hold significance if approached appropriately and with statistical rigor. It should be kept in mind that much previous research attempted to establish correlations between various phenomena and EQs but ultimately failed to do so, leaving the identification of a potential trigger for EQs as a still-open and very interesting topic of research.

## **Conclusions**

This communication presents a statistical analysis of reported SFs and registered EQ events conducted to investigate whether SFs

have a triggering effect on EQs in the Balkan Peninsula zone during the 24<sup>th</sup> SC. The analysis determined that although there are certain instances that warrant additional research, it is not possible to definitively establish a causal relationship between SFs and EQs or to utilize SFs as reliable predictors of EQs. In general, the evidence suggests that SFs are unlikely to be a factor in causing EQs.

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## **Environmental migration in the Balkans: Contemporary trends**

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**Abstract:** Environmental changes and disasters in the Balkan Peninsula affect society in different ways, including population mobility. This paper analyses statistical data on internal displacement according to different hazard categories and hazard types in the Balkans. The results show that population mobility in the Balkans is influenced by various environmental changes related to weather and geophysical hazards. Weather-related hazards such as floods and wildfires were found to have the greatest impact on population mobility in this area. Research has shown that the intensity of population mobility changes over time. The paper provides a starting point for a more detailed investigation of the relationship between population mobility and environmental changes in the Balkans in the future.

**Keywords:** population mobility, environmental changes, Balkan

### **Introduction**

Migration is a form of geographical or spatial mobility of population that refers to a change of residence between certain geographical areas. Changes in the environment have an

extraordinary impact on spatial mobility. Throughout history, people have left places with unfavorable environmental conditions and settled in areas with an optimal natural environment. In modern times, environmental characteristics are considered an important factor in the distribution of population on our planet (IOM, 2009; Šantić, Langović, 2023). Most environmentally driven migration is likely to take place within the country, and in the case of sudden extreme events (such as floods, storms, etc.), people usually migrate to a safe place nearby for a short period of time (ABD, 2011; SVR, 2023).

Global human mobility associated with weather-related and geophysical hazards has become a topic of scientific and political interest in recent decades (Beyer, Milan, 2023). Millions of people around the world are forced to leave their homes because of earthquakes, floods, desertification, droughts etc. Geophysical and weather-related hazards triggered 26.4 million new internal displacements, or movements, across the world during 2023. Floods and storms cause the most displacements on our planet. Projections suggest that by 2050, more than 200 million people worldwide could be forced to relocate within their country due to the effects of only climate change (EC, 2022; IDCM, 2024a).

The aim of this paper is to analyse the links between population mobility and environmental change in the Balkans. As the Balkan region is exposed to various geophysical and weather-related hazards, the focus is on determining the impact of different types of hazards on population mobility and analyzing the intensity of environmentally induced migration.

## **Methods and data**

This paper obtain data from the Internal Displacement Monitoring Centre IDMC (<https://www.internal->

[displacement.org/](https://displacement.org/)) on the number of internal displacements in the Balkans by hazard category (geophysical and weather-related) and hazard type (earthquake, flood, wildfire, storm, landslide/mass movement, extreme temperatures) for the period 2008-2023. Since the data refer to the national level, the calculation includes data for countries of the Balkan Peninsula - Serbia, Montenegro, North Macedonia, Bosnia and Herzegovina, Croatia, Slovenia, Romania, Bulgaria, Greece, Albania. The data are summarized in a Balkan database organized by the author of the paper. Data were processed in the SPSS software package.

## Results and discussion

The data analysis shows that the total number of internal displacements in the Balkan in the period 2008-2023 was 472,181 (Table 1).

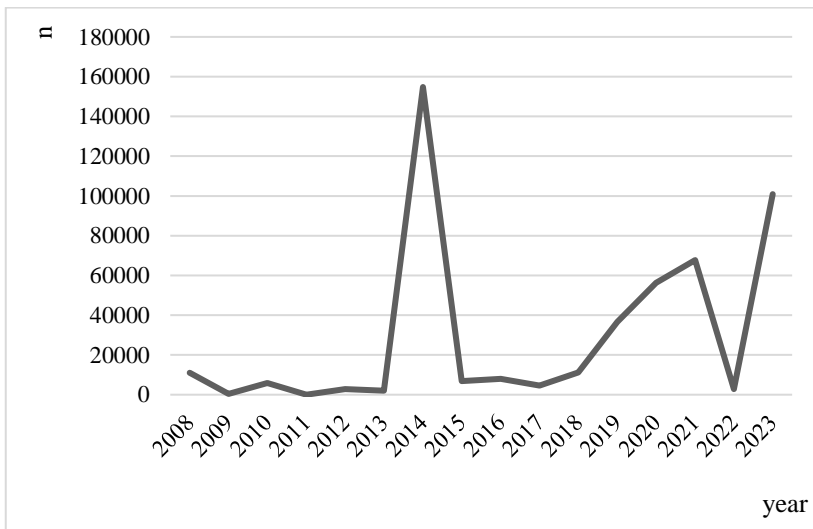
**Table 1.** Internal displacement in the Balkans by hazard category and hazard type, 2008-2023.

Hazard Category	Internal Displacements	Hazard Type	Internal Displacements	
			n	%
Geophysical	93.662	Earthquake	93.662	19.8
Weather-related	378.519	Flood	193.966	41.1
		Wildfire	156.880	33.2
		Storm	26.858	5.7
		Landslide/Wet Mass Movement	795	0.2
		Extreme Temperature	20	<0.1
In total			472.181	100

Source: Own work based on data from IDCM, 2024b.

It turns out that weather-related hazards have a particular influence on population mobility in the Balkans. Namely, weather-related hazards caused 378,519 internal displacements, while geophysical hazards caused 93,662 internal displacements. By type of hazard, the largest number of internal displacements was caused by floods. In the period 2008-2023, 193,996 internal displacements (41.1%) were caused by floods in the Balkan countries. This is followed by wildfires with 156,880 internal displacements (33.2%). Earthquakes as geophysical hazards caused 93,662 internal displacements (Table 1).

The results show that in the observed period of sixteen years, the year 2014 stands out, in which a total of 154,790 internal displacements were registered (Figure 1).



**Figure 1.** Total internal geophysical and weather-related displacement in the Balkans by years, 2008-2023.

Source: Source: Own work based on data from IDCM, 2024b.

In this year (2014), 8,226 (5.3%) internal displacements due to geophysical hazards and 146,564 (94.7%) internal displacements due to weather-related hazards were registered.

In addition to the year 2014, the year 2023 can also be highlighted, in which 100,948 internal displacements (weather-related only) were registered. The only year in which no internal geophysical and weather-related displacements were registered in the Balkans is 2011 (Figure 1).

## **Conclusions**

Environmental mobility in the Balkans is a reality. Therefore, it is necessary to investigate the relationship between population mobility and environmental change from different aspects. It is very important to focus, among other things, on the social dimension of the process - the living conditions after mobility and the possibilities and limitations of returning to the place of origin. This is particularly important for those who had to leave their homes due to floods, wildfires or earthquakes, which stood out to be the hazards that caused the greatest environmental mobility in the Balkans. Although such migration in the Balkans is usually temporary, there are also examples of people who were forced to leave their place of origin permanently due to damage to their property caused by one of the hazards. In future research, it is also important to consider the differences between these two categories of population - those who had to leave their place of origin temporarily and those who had to leave it permanently.

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## **Weather conditions influence on traffic crashes in the Republic of Serbia**

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**Abstract:** In this paper were analyzed traffic crashes in the Republic of Serbia that occurred as a result of unfavorable weather conditions. A total of 6,875 crashes were analyzed for the period from 2015 to 2023. The aim of this paper is to determine which of the sub-factors has the greatest influence on the number of traffic crashes. The analysis includes three parameters: slippery pavement, the impact of snow, rain, fog, etc., on visibility and the blinding of the driver by sunlight. The research showed that the slippery road has the greatest influence, as a factor that primarily affects the vehicle's controllability. Accordingly, the authors advise regular inspection and cleaning of the pavement, especially after snow and rain.

**Keywords:** traffic crashes, weather, slippery road, visibility, precipitation

### **Introduction**

The occurrence of traffic crashes can be related to various factors: external or internal. Four groups of influential factors are recognized in the literature: human, vehicle, road and

environment (Lipovac, 2016). Each of these elements contains a large number of sub-factors that influence the occurrence of traffic crashes to a greater or lesser extent.

In this paper, the impact of an external factor - the environment, namely weather conditions - on the occurrence of traffic accidents is analyzed. Weather conditions can be different, and for the purposes of this paper they are categorized into two groups: unfavorable weather conditions that have an effect primarily on the vehicle and its handling: rain, snow, ice, etc., and weather conditions that have an effect primarily on the driver: rain, snow, fog (from the aspect of visibility), as well as the blinding of the driver by sunlight.

A large number of authors have investigated the influence of weather conditions on traffic crashes. For example, in Finland, it was shown that the biggest influence has: hail and any weather that affects the appearance of slippery and very slippery pavement (Malin, Norros and Innamaa, 2019). According to the division defined in this paper, the mentioned impacts fall into the first category (impact on the vehicle). On the other hand, in Iran it has been shown that extreme cold, high temperatures and high air humidity have the greatest impact on traffic accidents (Eltemasi and Behtooiey, 2024). These influences can be classified in the second category (influence on human). In Greece (Athens), it was shown that the number of traffic crashes increases linearly with the increase in rain intensity (Theofilatos, 2019). This factor is very interesting because it can equally affect both the vehicle (by reducing friction due to aquaplaning) and the driver (by reducing visibility due to heavy rain). In the USA (Nebraska) it was shown that smaller amounts of snow on the road have the greatest impact on the occurrence of traffic crashes (Walker *et al.*, 2024), which is why the importance of regular cleaning and maintenance of roadways is emphasized.



In this paper was performed an analysis of traffic crashes in the Republic of Serbia that occurred as a result of unfavorable weather conditions. The aim of this paper is to determine which sub-factor within the environment element (weather conditions) has the greatest influence on the number of traffic crashes.

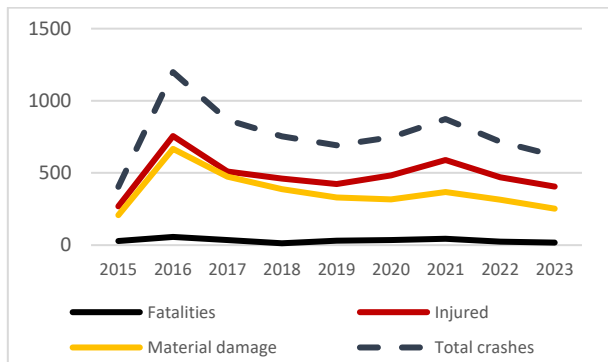
## **Methods and data**

For the purposes of this paper, an analysis of traffic crashes in the territory of the Republic of Serbia was performed, which occurred as a result of unfavorable weather conditions. The data used in this paper were taken from the website of the Road Traffic Safety Agency - Integrated database on traffic safety characteristics (<http://bazabs.abs.gov.rs/absPortal/>). The data covers the period from 2015 to 2023, during which 6,875 traffic crashes were recorded as a result of unfavorable weather conditions. All influential factors from the base, which are related to weather conditions, are included, namely: slippery pavement (result of precipitation), influence of rain, snow, fog, etc., on driver's visibility and influence of driver's blindness from the sun. Data were processed in the Excel software package, using standard statistical methods.

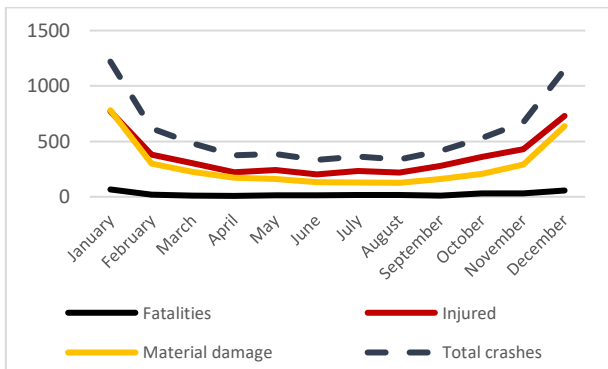
## **Results, discussion and conclusion**

For the purposes of this paper, traffic crashes were analyzed by type: total number of traffic accidents (6,875), number of fatalities (289), injuries (4,366) and material damage (3,317). Figures 1 and 2 show crashes by year and by month. It is interesting to note that the highest annual number of crashes was recorded in 2016, and then in 2021. The results obtained for 2021 are partly unexpected, considering the emergence of the COVID-19 pandemic, as well as the trend that during that period

the number of crashes in cities decreased, taking into account the closure of cities, restrictions on movement etc. (Escorcia Hernández *et al.*, 2023). On the other hand, it is quite clear why January and December are the months with the highest number of crashes: the winter period, with worse weather conditions, but also a higher vehicles flow due to the holiday season, which is consistent with other similar research (Seeherman and Liu, 2015).



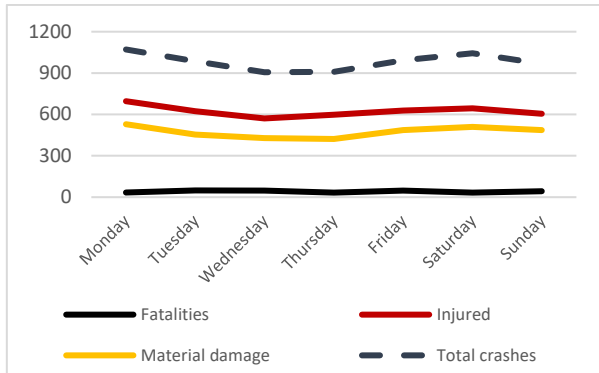
**Figure 1.** Traffic crashed by year



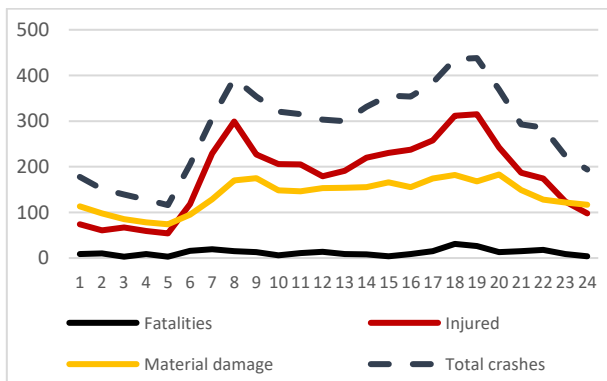
**Figure 2.** Traffic crashed by month

Figures 3 and 4 show the number of crashes by day and hour. The results coincide with the general trends of the occurrence of traffic crashes, which indicate that they most often

occur during Monday (the first working day), Friday and Saturday (the beginning of the first day of the weekend), as well as during peak hours (from 6 a.m. to 9 a.m. morning peak hour and from 5 p.m. to 8 p.m. evening peak hour), when the vehicle flow is the highest.

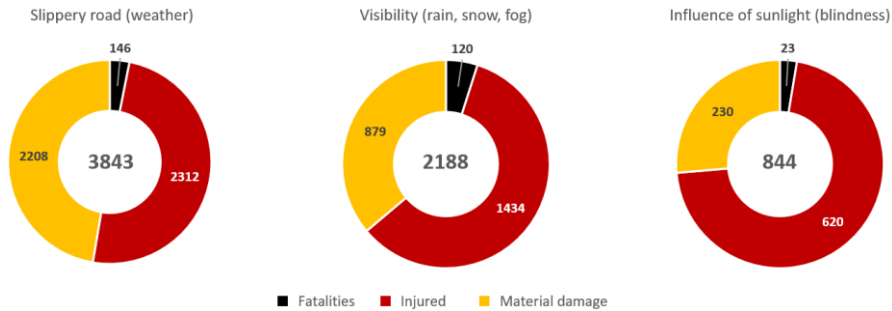


**Figure 3.** Traffic crashed by day



**Figure 4.** Traffic crashed by hour

Figure 5 shows the number and type of crashes in relation to the cause. In the middle of the circle is shown the total number of traffic crashes for each cause. As can be seen from Figure 5, the largest number of crashes (3843) and their consequences were recorded as the cause of slippery pavement (most often the result of rain and ice).



**Figure 5.** Traffic crashes by the cause

Such results coincide the results of other researches, where slippery pavement was also observed as one of the main causes of traffic crashes, especially among young people. (Jonghak *et al.*, 2018; Eboli and Forciniti, 2020). Another cause of traffic crashes is reduced visibility (2188), as a result of unfavorable weather conditions: rain, snow, fog, etc. In the end, the blinding of the driver due to the influence of the sun in the total number of traffic crashes takes 12.3%, that is, 844 traffic crashes occurred as a result of the driver's blinding.

Based on the above, it can be concluded that slippery pavement is one of the most common causes of traffic crashes in Serbia. Accordingly, the author suggests regular maintenance and cleaning of roads, as well as timely and adequate notification of users (with traffic signalization) about the state of the roadway in real time.

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## **Active Transport: A Pathway to Greener Planet, Healthier and Happier Lives**

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### **Abstract**

Active transport is characterized by the passenger's physical effort, which directly contributes to movement. This includes walking, cycling, and other activities like swimming, canoeing, and skateboarding. The most common topics under active transport study are the health benefits of this form of movement and the risks and safety that active transportation entails. Cohort studies demonstrated significant health benefits of active transport, particularly in preventing diabetes and improving mental health. Active transport satisfies the participants, facilitates socialization, and significantly reduces air pollution, contributing to a greener planet. According to national data from 2019 in Serbia, 75.2% of adults walk for at least ten minutes daily. On the contrary, only 9.0% of adults ride a bicycle daily, mainly in Vojvodina. The environmental benefits of active transport outweigh its dangers and risks. New designs of active transport vehicles provide opportunities and challenges in their implementation and spatial arrangement.

**Keywords:** active mobility, non-motorized transport, walking, cycling

## Introduction

Cook and colleagues defined active transport as transport “in which the sustained physical exertion of the traveler directly contributes to their motion.” (Cook et al., 2022). In practice, this would mean that in addition to walking and cycling, active transportation includes a whole series of disciplines with their variations: swimming, canoeing, kayaking, and rafting; skateboarding, rollerblading, and roller skating; traveling in a manual wheelchair, riding a bicycle with an electric motor and kick-scooting; ice skating, nordic skiing, etc... Forms of transportation that do not qualify as active travel include using any means of transportation entirely powered by a motor. Horse riding is not an active transport for a person but for an animal. However, maintaining a horse requires considerable physical effort; even riding requires the rider's entire body activity (Elmeua Gonzalez and Sarabon, 2020).

Active transport, or active travel, is the original form of people transport and fosters a sense of community and social interaction. It is a term gaining popularity, especially among decision-makers and public policymakers, as an alternative to “motorized transport,” the original form of people transport; it is a new term especially popular with decision-makers and public policymakers as an alternative to “motorized transport” (Allen and Nolmark, 2022). The review from 2022 found 658 papers in English in the Web of Science database published from 2000 to 2020, with the keyword “active transport” focusing on human transportation. This review is significant as it provides a comprehensive overview of the research related to active transport, highlighting the growing interest and the diverse range of topics being explored (Cook et al., 2022). Overall, about two-thirds of the works belong to the field of public health, and one-third to the transport field (Cook et al., 2022). Outside the

field of public health, terms such as “non-motorized transport” and “active mobility” are more commonly used in discussions about transportation or urban planning (Pisoni et al., 2022). This area of research, focusing on the benefits and challenges of active transport, has seen a significant surge in interest since 2010. The increasing interest in sustainable transportation and the health benefits of physical activity have contributed to this growth, with a particularly notable increase in research output since 2020, when epidemiological measures rested public transport, pointing out the importance of other forms of transportation (Allen and Nolmark, 2022).

In this paper, we will present some advantages and disadvantages of active transport with local Serbian data and compare them with the international prevalence of such transport.

### **Benefits of active transport**

As it was said, active transport is a rising topic in public health. Therefore, it's hardly surprising why so many researchers evaluate the benefits of active mobility to human health, making this subtopic the most intriguing one within all active transport. This interest is based on the proven increase in obesity, a disease per se and a risk factor for other diseases, and the simultaneous increasing use of motorized traffic at the expense of walking. Therefore, active transport sounds like a logical way to increase physical activity. World Health Organization (WHO) reminds us that a regular walk of at least 30 minutes or a bicycle ride of at least 20 minutes reduces the frequency of cardiovascular diseases and diabetes, as well as cancer deaths (World Health Organization, 2022).

However, there is a clear need for more comprehensive studies to provide unequivocal evidence of the health benefits of



active transport through interventional, cohorts, and case-control studies (Saunders et al., 2013). One of the reasons for such unclear results is the short duration of the studies and the type of studies with a predominance of cross-sectional studies where it is difficult to separate cause from effect. The most unmistakable evidence was found for walking longer than 20 or 30 minutes to prevent type 2 diabetes, supporting WHO recommendations (Sato et al., 2007, Hu et al., 2007). Kroesen and De Vos analyzed a Dutch cohort of adults over ten years and found that a high Body Mass Index was associated with avoiding active transport. On the other hand, walking and cycling are strongly associated with better mental health (Kroesen and De Vos, 2020). This cohort research agrees with previous findings suggesting that walking or cycling to work are the forms of transport that contribute the most to our positive mood (De Vos et al., 2016, St-Louis et al., 2014).

Additionally, active transport significantly contributes to fun and satisfaction, which are legitimate children's and adults' needs. Those who walked or cycled to work reported better moods and work performance than passive transport users. This not only enhances personal well-being but also inspires personal growth and development (Fyhri et al., 2023). Cycling to work, but not walking, was associated with reduced sickness absence, a promising finding for employers concerned about absenteeism (Mytton et al., 2016). Therefore, if business owners invest in bicycle parking spaces, lockers, and changing rooms, they might attract happier, healthier, and more efficient employees who will be less absent.

Sometimes, it is not easy to separately analyze the satisfaction achieved by active transportation from situations where transportation is the primary goal of the activity that brings happiness and satisfaction to the participants. Besides all the benefits of moderately intensive exercise on the mood, other

components cause high commute satisfaction amongst cyclists. Those are 1) A high level of commuting control, "arrival-time reliability" with a sense of "self-efficacy" early in the day; 2) Pleasant levels of sensory stimulation from a combination of internal sensations due to muscular effort with sensory input from the different landscapes, blue and green spaces; and 3) Greater opportunities for social interaction and neighborhood satisfaction (Toner et al., 2021, Wild and Woodward, 2019). We have all witnessed rivalry or even unpleasant situations between motor vehicle drivers in traffic or public transport drivers and passengers at least once in our lives. Such inconveniences are almost non-existent between cyclists, and riding together provides an opportunity for "flexible" social interaction. The use of electric bicycles in commuting can further increase all these benefits.

According to Lelieveld et al., the global mortality due to ambient air pollution from fossil fuels is more than five million annually (Lelieveld et al., 2023). Transport is a major source of emissions that contribute to outdoor air pollution (Anenberg et al., 2019). Therefore, active transportation unequivocally contributes to health indirectly through a cleaner environment. Evidence from a study conducted in eight European cities showed that replacing one trip per day during 200 days by car with one trip by bicycle would decrease mobility-related lifecycle CO<sub>2</sub> emissions by about 0.5 tonnes over a year (Brand et al., 2021). This study demonstrates an excellent potential for reducing ambient air pollution due to switching from motorized to active transport. The results become more critical if the frequency of car driving is known for short distances that can be overcome by walking or cycling up to a distance of 8 or 16 kilometers. These short routes disproportionately contribute to air pollution, especially in the northern hemisphere and during winter (Neves and Brand, 2019, Brand, 2021).

The final benefit that we will present is decreasing social exclusion, defined in mobility and transport as circumstances that make it challenging to access services, goods, and opportunities and to be involved in society (MacLeod et al., 2022). Active transport contributes to the inclusion of a broader range of people, children, the poor, and people with disabilities in social life, making social activities (work, schooling, social events...) accessible to people who, due to age, disability, or modest financial possibilities, cannot afford "classic forms of transport" or they live in areas without suitable transport infrastructure (Yuan et al., 2022). The importance of transport as a vital need of people was seen during the lockdown period of 2020 when a large part of public transport stopped working. Such a measure may have limited the spread of the virus, but it significantly contributed to isolation, alienation, and feelings of sadness and loneliness, especially among older people (Yang et al., 2021).

With the development of new active vehicles, the benefits of active transportation are growing. A good example is electric-assist bicycles (e-bikes) (Castro et al., 2019). Contrary to popular belief, e-bikes require more physical engagement than regular bikes. In addition, such bicycles were found to cover longer distances in total and per day. However, this mean of transport is associated with higher speed. Therefore, if stakeholders would like to accommodate or promote this way of sustainable transport and avoid clashes with other traffic participants in urban areas, they need to adapt and expand cycling infrastructure according to their demands and special safety needs.

## **Problems associated with active transport**

Active travel does not come without issues (Cook et al., 2022). Security of such transport is the second most common topic in active transport within public health. Roadways are constructed according to the needs of motorized traffic. Therefore, users of these motorized means of transport are not used to participating in traffic with “non-motorized” means of transport, nor are they trained enough. That is why they fear meeting cyclists, someone in wheelchairs, or kick-scooting riders. Even with the best protection measures, active transport participants are vulnerable to collisions with motor vehicles, which could lead to fatal outcomes.

That close contact of active travel with the environment and the continuous surrounding of sensations can be pleasant. Still, it can sometimes be so strong that it makes a pedestrian or a cyclist lose their sense of reality, with a consequent loss of concentration, which can be fatal in traffic without collisions with other vehicles.

The public also associates active transport with extreme and risky behavior. It tends to overestimate the prevalence of injuries or deaths of cyclists, skiers, skaters, or canoeists rather than other road users, especially motor vehicle drivers (Fang and Handy, 2017). The traditional statistics classify all these forms among pedestrians, contributing to this, so it is challenging to determine the true extent of national suffering among skateboarders, rollerblades, or Nordic skiers. It should be noted that the behavior of active drivers on the road is different from their behavior on artificial training grounds specially designed for vet skateboarding or freeride BMX (Fang and Handy, 2017).

Ensuring the equality of all types of active transport is a particular group of problems. Considerable resources have already been invested in the development of cycling and

walking, and the question arises whether the community would be willing to promote the development of other forms of active transport similarly. Is the development of paths for other forms of active transport too much of a demand for the community, and will it come at the expense of the deprivation of cycling?

As already said, active travelers are in constant contact with the environment. Therefore, it is considered that active travelers are exposed to environmental factors much more than passengers in motor vehicles. It includes air pollution, also. However, studies show they are less exposed to CO, volatile organic compounds, or PM than other travel modes at shorter distances. Although this exposition is still elevated compared to ambient levels (de Nazelle et al., 2011). Exposure depends on many factors, including population density, traffic density, distance from pollution sources, airflow, etc. It should be remembered that active travelers can choose their routes, which is why most of them select safer roads due to pollution and protection from injuries. Exposure to pollution increases with the length of the road, both due to more prolonged exposure to sources of pollution and the increase in inhalation. Long-term exposure to polluted air decreases but does not cancel out benefits from active transport (Mueller et al., 2015). However, the level of reduction depends on the degree of inundation of a particular area and spece (Chandia-Poblete et al., 2022). Even traffic trauma does not negate the health benefits of active transport (Mizdrak et al., 2019).

Finally, but not less important, is the legal regulation of their participation in traffic in light of the development of new types of active transport. Similar to this are challenges of urban planning and the arrangement of open and closed spaces that could safely accommodate all road users. Improving urban and transport planning will result in more carbon-neutral, liveable,

and healthier cities for both active travelers and inhabitants (Nieuwenhuijsen, 2020).

## **The utilization of active transport in Serbia**

Questions about active transport in Serbia are an integral part of research on the health status of the Serbian population, which is periodically conducted. The last such study was carried out in 2019. There are four questions about active transport:

- FA.2 Question: In a typical week, how often do you WALK for at least 10 minutes a day without interruption (continuously) to go or return from somewhere?
- FA.3 Question: How long do you usually walk during the day to go or return from somewhere?
- FA.4 Question: In a typical week, how often do you CYCLE for at least 10 minutes a day without interruption (continuously) to go or return from somewhere?
- FA.5 Question: How long do you usually spend riding a bicycle during the day to go or return from somewhere?

Data on the frequency of habits are standardized based on sex and age to obtain more representative data. All data refer to a population aged 15 and above.

Regarding question FA.2, about the number of days of walking during the week, 75.2% of the population stated that they walk for 10 minutes or more continuously every day, slightly more men (76.1%) than women (74.3%). Daily walking is the most common among the youngest (age group 15-24), about 84.1% of such population. With each subsequent age group, the frequency of daily walking as a visible form of transportation decreases, so that among those aged 85 and over, this habit is present in only 42.3% of this age group. Among the regions, everyday walking was the most frequent in Southern and Eastern

Serbia (82.8%) and the least frequent in Šumadija and Western Serbia (68.0%). As for the frequency according to household income quantiles, Serbian residents in the first quantile, which includes the poorest households (76.7%), are the most regular walkers and those from the fourth quantile (76.4%) are very close to them.

As for the usual time they spend walking, 33.9% of the population stated that they walk from 10 to 29 minutes a day, and an additional 28.8% walk from 30 to 59 minutes. Among those who walk daily for more than 10 minutes, 26.9% walk up to 29 minutes and 29.8% walk from 30 to 59 minutes.

If the majority of Serbs regularly walk, the situation is the opposite when it comes to cycling. Almost four-fifths of the adult population of Serbia (76.8% to be exact) did not ride a bicycle for even 10 minutes at least once a regular week. Those who ride a bike do it daily, so 9.0% of adults rode it daily for more than 10 minutes, mostly men (10.5% compared to women with 7.6%). Adults aged 55-64 (10.9%) travel by bicycle most often daily, whereas those in the younger age group 45-54 do it a little less (10.3%). By far, adults in Vojvodina (23.5%) ride a bicycle daily, while the least common are adults in Belgrade (1.8%). Adults from the poorest households most often ride a bike every day, and those from the wealthiest quantile the least.

When asked how much they ride a bicycle when they travel, 48.5% stated that they ride for up to 29 minutes, and 33.2% intervals of 30-59 minutes. Among daily cyclists, 38.7% travel by bike for up to 29 minutes, and 38.6% travel from 30 to 59 minutes.

## **Comparison with European counties**

Eurostat is the statistical office of the European Union (EU). It regularly publishes data on physical activity for the EU

countries, the European Free Trade Association countries, and the countries that are candidates for membership in the EU, including Serbia (Eurostat, 2022). According to their data, 82.6% of the adult population walks for 10 minutes at least once a week at the EU level. That is significantly less than Serbia, where that percentage is 93.2%. Of the surrounding countries, Bulgaria's population walks more, while Croatia, Hungary, and Romania walk less.

As for cycling, Serbia is slightly behind the EU average. The frequency of bicycle transportation for more than 10 minutes at least once a week in Serbia was 23.2%. At the same time, this prevalence was 23.6% at the EU level among the adult population in 2019. Transportation by bicycle for more than 10 minutes at least once a week is practiced more often in Hungary than in Serbia and less often in Bulgaria, Croatia, and Romania. As expected, the highest cycling frequency was in the Netherlands, followed far behind by Denmark in second place.

The bicycle is one of the symbols of the Netherlands. In 2019, more than a quarter of all trips were made with it, but only about 8% of all distances were covered by bicycle (KiM Netherlands Institute for Transport Policy Analysis, 2020). This means that bicycles are used for frequent trips over short distances. Thus, the average Dutch person travels about 3 kilometers a day by bike. Cycling is a favorite pastime in the Netherlands; about a third of all trips were related to fun and enjoyment. The rest is evenly distributed between shopping, going to and from school, commuting, and other purposes. This popularity of cycling in the Netherlands results from a combination of tradition, favorable climate, and terrain, which has been improved by interventions that have been made to popularize the daily use of bicycles. These interventions include providing adequate cycling infrastructure and reducing the attractiveness of car use (e.g., by increasing parking tariffs and



increasing the area of paid on-street parking) (Harms et al., 2016). Such an approach is figuratively called the "carrot and stick" approach. The effectiveness of the intervention owes its scientific basis to setting achievable and measurable goals. Monitoring the objectives enables tracking the implementation of promotional programs and their correction on the ground in real-time according to interim goals.

## **Conclusions**

Active transportation is one of the ways to build a sustainable, healthy, happier, and cleaner future, especially in urban areas, where participation in social activities and access to goods and services require short trips. Serbia has further potential for the development of active transport, especially cycling. In this sense, the evidence from the literature suggests that the target groups should be younger people who do not use this type of commuting at all. Promotion activities should establish and develop an active mobility culture regardless of the weather or season of the year.

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## **Cosmic Rays and Their Connection to Space Weather and Earth's Climate**

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**Abstract:** Cosmic rays have been studied for over a century. In addition to investigating their fundamental properties, such as origin, composition, and acceleration mechanisms, some of the most important studies in the field involve the interaction of cosmic rays within the heliosphere, near-Earth space, and the immediate Earth's environment. These areas have been of particular interest in recent years.

One such type of study focuses on the modulation of cosmic rays by the solar magnetic field and the geomagnetic field in the heliosphere and Earth's magnetosphere, respectively. Among other things, the study of these modulations allows for the indirect observation of solar events, which produce characteristic signatures in the interplanetary magnetic field.

Another interesting aspect of cosmic ray physics involves the interactions of secondary cosmic rays, primarily the muon component, within Earth's atmosphere. Precise models of these interactions allow for corrections for atmospheric effects to be made to the muon flux, increasing the sensitivity of Earth-based detectors. Additionally, these models can enable inverse

diagnostics of the atmosphere, potentially providing an additional technique for atmospheric sounding.

Thus, precise monitoring of cosmic ray variations can serve as a proxy for measuring solar activity and variations in Earth's atmosphere. This can be invaluable in situations where direct measurements are not available and can provide significant contributions to the study of space weather and Earth's climate.

**Keywords:** cosmic rays, solar physics, atmospheric effects, space weather, Earth climate



## **Cosmic rays as a clock (or Using cosmic rays for imaging and to study past)**

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**Abstract:** Earth is constantly bombarded by cosmic rays, high-energy charged particles, mostly protons, coming from our galaxy. Heliosphere and geomagnetic field can modulate and suppress cosmic rays flux (1). But some particles are sufficiently energetic to reach Earth's atmosphere. On impact with common atoms in Earth's atmosphere and crust, they break apart these atoms to create new rare isotopes known as cosmogenic nuclides (2). The rate of their production is determined by several factors like intensity of primary cosmic rays, the level of solar activity, strength of the Earth's magnetic field, etc.

Quantitative information about past solar and geological activity and even archeological findings over long timescale can be obtained using a method based upon cosmogenic isotopes as indirect proxies.

In addition, non-destructive emerging imaging technics like cosmic ray muons tomography and radiography use the natural radiation of cosmic ray muons to create 2D and 3D images of objects (3). This work will review some of the uses of cosmic rays that can find applications in a wide variety of fields, from astronomy, geology, and archaeology to biology, engineering, and security.

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# *Lectures*

## **Solar Wind and Seismic Activity in the Balkan Peninsula: a 2019- 2023 Progress Report**

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**Abstract:** This brief progress report provides an update on the ongoing research that aims to test the statistical significance and explore the potential causal relationship between earthquakes and increased solar wind parameters, distinguishing whether these events occur randomly or are interconnected. The updated research confirmed that heightened solar wind parameters, such as proton density and velocity, cannot be differentiated from the random distribution of these events prior to earthquakes in the Balkan Peninsula region.

**Keywords:** proton density, proton velocity, earthquakes

### **Introduction**

Previous research correlating solar wind parameters to global increased seismic activity displayed a positive correlation between the two (Marchitelli et al. 2020). In the study conducted by Arnaut et al. (2021), the researchers examined the correlation between heightened solar wind parameters, specifically proton density and velocity, and their potential to trigger earthquakes (EQs) in the Balkan Peninsula region. The research findings

indicate that there is no causal relationship that can be distinguished from random chance.

Inferring a causative relationship for EQs and any causing external factor is a difficult task due to the complex subsurface activities that cause them. However, several mechanisms have been proposed. An example of such a mechanism is the magnetohydrodynamical interaction between the solar wind and the Earth's magnetic field, which can influence the rotational velocity of the Earth (Simpson, 1967). This, in turn, can impact the timing of EQs and potentially lead to a shorter timeframe for their occurrence. Marchitelli et al. (2020) proposed a mechanism in which a reverse piezoelectric effect initiates subsurface currents that subsequently destabilize fault zones and induce EQs. The solar wind induces heightened subsurface currents, while the EQ is primarily tectonically driven, although its initiation is influenced by external factors.

Both mechanisms are rooted in physical principles. However, the objective of previous and subsequent studies is to determine the statistical significance of these events. The goal is to determine whether the anomalies can be differentiated from random chance when given the same input parameters. This brief progress report presents the continuation of analysis conducted in the original research paper (Arnaut et al. 2021) covering the period 1996-2018, incorporating updated data with a time span of 2019 to 2023.

## **Methods and data**

The dataset used in this research employed EQ data from the EQ catalog of the United States Geological Survey (<https://earthquake.usgs.gov/earthquakes/search/>). The retrieved data comprised of EQs that occurred between 2019 and 2023 in the region encompassing the Republic of Serbia and its

neighboring countries. The data specifically included EQs with a magnitude of  $M \geq 5.0$ , which aligns with the methodology presented in Arnaut et al. (2021).

The proton density and velocity of the solar wind were acquired from OMNIWeb (<https://omniweb.gsfc.nasa.gov/form/dx1.html>), which collects data from the Solar Heliospheric Observatory (SOHO). The SOHO satellite positioned at the L1 Lagrange point (beyond Earth's magnetosphere) measures various parameters, including in situ measurements of the solar wind (Ipavich et al., 1998).

An anomalous day, as was defined in Arnaut et al. (2021), refers to any day in a given year where at least one value for proton density or velocity exceeds the mean for that year by three standard deviations. Further statistical analysis was conducted to determine which EQs exhibited an anomalous day within 14, 7, 4, or 1 day(s) prior to the EQ itself.

## **Results and discussion**

The analysis results revealed that all EQs had an anomalous value for the proton density parameter in the 14 and 7 days leading up to it (Table 1). By contrast, the percentages from the previous analysis conducted between 1996 and 2018 were 80 and 62 percent, respectively. Regarding the four days leading up to the EQ, the findings remain relatively consistent with the previous analysis. In the sample of EQs from 2019 to 2023, 7 out of 20 EQs (35%) had an anomalous proton density day, which is in congruence to the 46% observed in the period from 1996 to 2018. Additionally, only 6 out of 20 EQs (30%) displayed an anomalous proton density value in the day preceding the EQ.

**Table 1.** Results of the conducted analysis for period 2019-2023

EQ date-time	Two-weeks		One-week		4-days		1-day	
	PD	PV	PD	PV	PD	PV	PD	PV
2/14/2023 13:16	•		•					
2/13/2023 14:58	•		•					
11/3/2022 4:50	•		•					
4/22/2022 21:07	•		•		•			
3/27/2021 13:47	•		•		•		•	
12/29/2020 11:19	•	•	•	•				
11/11/2020 3:54	•		•		•		•	
3/22/2020 5:24	•		•					
1/28/2020 20:15	•		•		•		•	
11/28/2019 10:52	•		•		•		•	
11/27/2019 14:45	•		•					
11/26/2019 9:19	•		•					
11/26/2019 6:08	•		•					
11/26/2019 3:02	•		•					
11/26/2019 2:59	•		•					
11/26/2019 2:54	•		•					
9/21/2019 14:15	•		•		•		•	
9/21/2019 14:04	•		•		•		•	
6/1/2019 7:00	•		•					
6/1/2019 4:26	•		•					

EQ- Earthquake; PD- Proton density; PV- Proton velocity;  
 •- confirmed anomaly

From the previous research, the proton velocity parameter displayed anomalous values of 56%, 32%, and 18% for the periods 14, 7, and 4 days prior to the EQs, respectively. Only one EQ exhibited an anomalous proton velocity value during the 14 and 7 days leading up to the EQ.

Applying the same simulation procedure as conducted in Arnaut et al. (2021), it was determined that the anticipated number of EQs exhibiting an anomalous proton density within the two weeks preceding them is 19.58. This finding aligns with the observed occurrence of 20 out of 20 EQs. During the one-week timeframe, the value is 17.2, which is relatively close to the value obtained, which is also 20. The expected value for the 4-day period is 13, while the obtained value is 7. The close proximity between the expected/simulated values and the true values are so minimal that it is impossible to distinguish a random occurrence from any other possible correlation. This conclusion aligns with findings from previous research (Arnaut et al., 2021).

## **Conclusions**

This brief progress report presents ongoing research on identifying any possible correlation between solar wind parameters (such as proton density and velocity) and EQs that have taken place in the Balkan Peninsula region. The examination of EQ and solar wind data spanning from 2019 to 2023 has reaffirmed previous obtaining that differentiating between the presence of heightened solar wind parameters and registered EQs is exceedingly challenging, as it is difficult to ascertain whether their co-occurrence is merely a result of random chance or possible causal relationship indicator. The most likely explanation is that solar wind cannot be definitively identified as a trigger of EQs registered on the Balkan Peninsula.



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## **Linkages between internal displacement and climate: Evidence from Serbia**

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**Abstract:** The paper analyses the relationship between internal displacement and climate in the Republic of Serbia in the last fifteen years. The results show that weather related hazards have an impact on internal displacement, influencing very specific characteristics of population mobility. It was found that floods have by far the greatest impact on the intensity of population mobility. As it is influenced by the climate conditions, this type of population mobility stands out from other types of migration in Serbia. Namely, internal displacements influenced by weather related hazards are primarily temporary and depends solely on the characteristics of the climate, and requires urgent and specific governmental support. For this reason, studies connecting internal displacement and climate require a different approach.

**Keywords:** internal displacement, climate, Serbia

### **Introduction**

Climate change is one of the greatest challenges of our time. The effects of climate change are numerous and include

severe environmental degradation and extreme weather events (heavy rainfall, droughts, heatwaves, etc.) that can affect people in different ways. It is recognized that climate change is increasingly leading to the displacement of people. Given the complexity of the relationship between climate and mobility, it is important to emphasize that climatic or natural hazards do not automatically lead to displacement (Piguet et al., 2011; EMN, 2023). However, official data show that millions of people around the world have been displaced by climate change. Some researchers point out that environmental changes, including climate change and environmental degradation, have become the “new normal” (Rojas Paz, 2022; IDCM, 2024).

Although climate change is a reality in both developed and developing countries, it is expected that the population in developing countries will be more affected by these changes and will be forced to migrate to a greater extent. Indeed, in less risky or more stable environments, the exposure of an individual or household to climate change may be greater and displacement from these areas is more frequent (Reuveny, 2007; IOM, 2009). Population mobility triggered by weather related hazards can pose numerous challenges for communities, and adaptation to these challenges will primarily take place at the municipal level (Nourali et al., 2024).

Understanding the link between climate and population mobility requires both social and natural science perspectives (Andrews, 2020). This paper analyses the intensity of internal displacement in the Republic of Serbia in relation to weather-related hazards over the last 16 years (2008-2023). The aim is to recognize and highlight the weather-related hazards that have the greatest impact on the internal displacement in Serbia in this context, and to determine the characteristics of the process.

## Methods and data

This paper analyses statistical data on internal displacements by weather related hazards in the Republic of Serbia acquired from the Internal Displacement Monitoring Centre IDMC (<https://www.internal-displacement.org/>). Data were processed in the SPSS software package. In order to better understand the internal displacement caused by weather related hazards, a detailed review of the literature on this topic was carried out. A particular focus is on the displacement conditions of persons who had to leave their homes due to the floods that occurred in Serbia in 2014.

## Results and discussion

In the period 2009-2023, the total number of Internal Displacement in Serbia is 38,371. The data indicate that the floods have affected the largest number of Internal Displacements (38,029) (Figure 1).

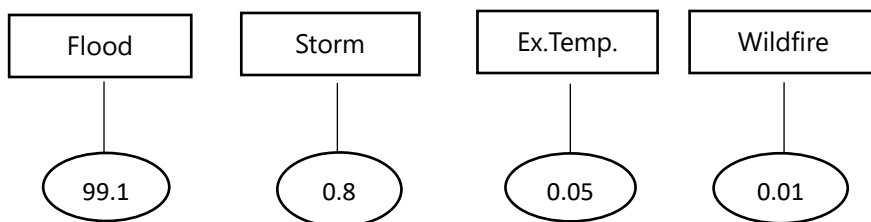


Figure 1. Internal displacement by weather related hazards in Serbia (%), 2009-2023.

Source: Own work based on data from IDCM, 2024.

Internal displacement due to floods accounts for 99.1% of all internal displacement caused by weather related hazards. In addition to floods, the population was also displaced by other hazards during this period, but to a much lesser extent. Storms

caused 320 internal displacements (0.8%), extreme temperatures 20 (0.05%) and forest fires 2 (0.01%) (Figure 1).

Although internal displacement due to floods was characteristic for a larger number of years in the observed period (2010, 2014, 2016-2023), it is clear that the floods in 2014 caused the highest intensity of internal displacement (33,360/86.9%). Compared to the other years, the floods in 2010 also caused a slightly higher number of internal displacements (3,000/7.8%). Internal displacement due to storms was recorded in 2023 and forest fires and extreme temperatures (cold wave) in 2013 (Table 1).

Table 1. Internal displacement by weather related hazards in Serbia by years, 2009-2023.

Year	Weather related hazard type	Internal Displacements	
		n	%
2009	/	/	/
2010	Flood	3000	7.8
2011	/	/	/
2012	/	/	/
2013	Wildfire	2	0.01
2013	Flood	172	0.4
2013	Extreme Temperature	20	0.05
2014	Flood	33360	86.9
2015	/	/	/
2016	Flood	39	0.1
2017	Flood	42	0.1
2018	Flood	125	0.3
2019	Flood	292	0.8
2020	Flood	880	2.3
2021	Flood	34	0.1
2022	Flood	1	<0.01
2023	Flood	84	0.3
2023	Storm	320	0.8

Source: Own work based on data from IDCM, 2024.

The heavy rains that hit Serbia in May 2014 led to floods that affected around 1.6 million people in 38 municipalities and cities, mainly in central and western Serbia. The heavy rainfall caused landslides, that led to the collapse of houses, roads, bridges and other parts of the infrastructure. Most of the displaced people were accommodated with their relatives, while some of them were temporarily accommodated in camps set up by the government and the Serbian Red Cross (UN, EU and WBG, 2014). One of the surveys conducted during this period found that the biggest problem for most IDPs was leaving their homes and property, followed by how to get on a boat and how to get through the water. The biggest problem for people staying in collective shelters was the uncertainty about their return - when and if they will return, but also what the situation is like in their places and homes (Baćanović, 2014).

## **Conclusions**

As in most parts of the world, climate is also having an impact on population displacement in Serbia. This type of population mobility is not continuous, but only temporary and occasional on the territory of Serbia. Since the population is forced to leave the country, weather related displacement can be considered a form of forced migration. Floods are categorized as weather related hazards that are primarily related to internal displacement. It is therefore important that future research on this topic is conducted in flood-prone areas.

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## Traffic accidents in winter conditions for the Republic of Serbia

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**Abstract:** Traffic safety is influenced by numerous factors that can be grouped into four categories: the human element, the vehicle, the road, and the environment (Pešić, Antić and Lipovac, 2023). In the Republic of Serbia, during the year 2022, there were 33,230 traffic accidents. This paper analyzes the impact of the environment on the occurrence of accidents, with a focus on accidents that occurred during the winter period due to the influence of specific weather conditions and environmental factors.

**Keywords:** traffic accidents, environment, weather conditions

### Introduction

Traffic safety is an interdisciplinary and intermodal science that broadly studies all negative consequences of traffic. In a narrower sense, traffic safety examines traffic accidents as one of the major causes of traffic insecurity. Factors influencing the occurrence of traffic accidents are classified into four categories: human, vehicle, road, and environment. These four factors together constitute an expanded Hedonic Safety Factor Matrix



for traffic safety (Pešić, Antić and Lipovac, 2023). Each of these factors contains a large number of sub-factors that influence safety. The environment includes weather conditions, roadside environment, healthcare, and more.

Although the trend in the Republic of Serbia in recent years has been a decrease in the number of traffic accidents, the goal of traffic safety remains the same as to reduce accidents. *The misconception is that only a mistake or unsafe behavior of drivers causing traffic accidents, in almost all cases. The results of study the causes of road accidents show that in every third of road accident road environment has a significant impact (Trifunović, et al, 2019).*

This research aims to highlight the differences between the number of traffic accidents during winter and other periods, the variations in the severity of traffic accident consequences, and to point out characteristic situations that may lead to accidents during winter periods.

## **Methods and data**

For the purposes of this research, data from the Traffic Safety Agency's database and an interactive map created by the same entity were used. Traffic accidents were categorized according to the months they occurred. The consequences of traffic accidents were categorized as accidents resulting in: material damage, injuries and fatalities. For the purposes of the research, data from the most recent available year, 2022, were used. In 2022, there were 33.230 traffic accidents in the Republic of Serbia (Road traffic safety agency, 2022). Figure 1 provides a graphical representation of the number of traffic accidents categorized by the type of consequences.

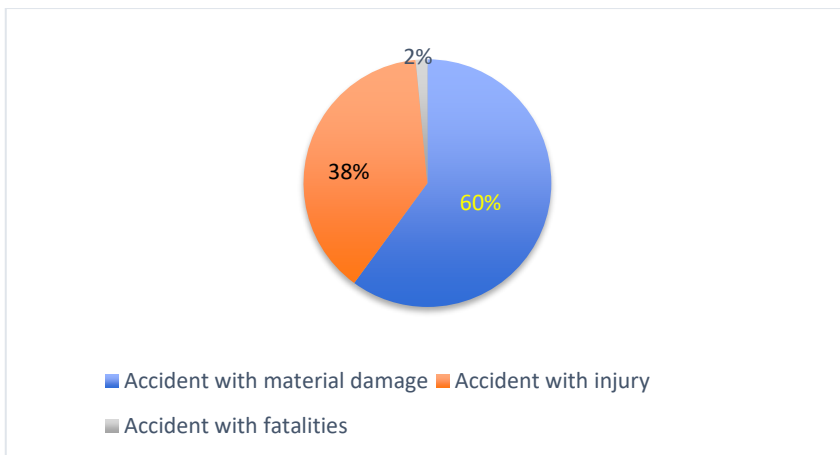


Figure 1. Accidents by the type of consequences

From the previous figure, it can be seen that in 2022, the majority of traffic accidents resulted in material damage (19,961 accidents), while the fewest accidents resulted in fatalities (505 accidents). One of the issues in Serbia is the underreporting of accidents with minor material damage, so this number of accidents should not be considered final. The highest number of fatal accidents occurred in July (59 accidents), as well as a large number of accidents with injuries. The fewest fatal accidents occurred in February (28 accidents). During the winter months, a lower number of fatal accidents (110 accidents) is recorded compared to other seasons of the year, as can be seen in the following table.

Table 1. Accidents by season

	Accident with material damage	Accident with injury	Accident with fatalities
Spring	5.071	3.079	113
Summer	4.693	3.410	150
Fall	5.126	3.444	132
Winter	5.071	2.831	110

When all traffic accidents are summed by season according to Table 1 (Агенција за безбедност саобраћаја, 2022), it results in the lowest number of accidents occurring in winter. In 2022, most accidents occurred during autumn (8,702 accidents), while the number of accidents was approximately the same in spring and summer.

## **Results and discussion**

The data show that the fewest accidents occur during the winter months, which may be expected given that environmental conditions are particularly challenging during this time. Due to these environmental conditions, road users pay more attention to their surroundings to avoid accidents. This is reflected in the reduction of driving speed, which is often a cause of accidents as well as the severity of their consequences.

Some of the causes of accidents that should be addressed include young drivers. During intense snowfall at night, young and inexperienced drivers instinctively turn on their high beams to improve visibility. In such conditions, high beams can have the opposite effect and completely block the driver's field of vision. Additionally, on lower-category roads where snow clearing services do not operate, snow can cover obstacles that may lead to accidents.

In Serbia, many local roads lack designated pedestrian areas, creating a risk that pedestrians may slip on ice during winter periods with low temperatures, potentially leading to accidents with serious consequences (Davidović, Antić, Pešić, 2024). The road maintenance services are responsible for managing vegetation alongside the road to prevent the accumulation of large amounts of snow on trees extending over the roadway. Due to the heavy weight of the snow, it may fall

onto a vehicle passing underneath, surprising the driver. This can lead to sudden maneuvers that may endanger both the driver and other road users.

## **Conclusions**

In Serbia, in 2022, there were 33,230 traffic accidents, of which 8,012 occurred during the winter months (Pešić, Antić and Lipovac, 2023). To reduce the total number of traffic accidents and the severity of their consequences during winter periods, it is essential to train young drivers to handle winter driving conditions. Additionally, improving the work of road maintenance services can contribute to traffic safety. Investing in technologies that better predict weather conditions could help drivers be more informed about upcoming weather, thus enhancing overall road safety.

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## **VLF radio signal propagation under severe stormy weather conditions**

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**Abstract:** Due to the ongoing climate change, extreme weather events globally came to attention primarily since their more frequent occurrence, especially during the last decade. Severe stormy weather conditions and interrelated electrification processes in storm-bearing clouds are well known to get into relation with Earth's ionosphere through a global electric circuit, forming in lithosphere-atmosphere-ionosphere coupling processes. Very Low Frequency (VLF, 3-30 kHz) radio-propagation, taking place within the Earth-ionosphere waveguide, is strongly under the influence of such conditions. Atmospheric electric discharges and related transient luminous events, common for severe stormy weather, through electric processes cause abrupt and intense changes in electrical properties of their surroundings. VLF signals, propagating sub-ionospherically, are strongly influenced by these regions of changed electric properties and undergo perturbations of distinct features, which can be used for studying related processes and phenomena, through a remote sensing approach. Characteristic perturbations observed on monitored VLF signals transmitted from USA, UK, Germany, Italy and France and registered in Belgrade, Serbia, related to stormy weather

conditions in region over Balkan Peninsula during the last decade, were examined, with main findings presented in this research.

**Keywords:** stormy weather, electric discharges, radio-propagation, VLF perturbation

## Is demography a real problem for sustainability?

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**Abstract:** The impact of a growing population on the environment has been a focus of interest for many years. This is because of the well-known links between more people on the planet, growing wealth and consumption, and increasing environmental degradation. However, less attention has been paid to the environmental impacts of a stagnant and possibly shrinking population. The relationship between demographics and sustainability is fraught with significant contradictions. It appears that growth is critical to the planet because population is a major cause of environmentally damaging emissions, impacts, or resource use. However, halting population growth would accelerate population ageing, resulting in a decline in the labour force and an increase in the proportion of economically dependent people. Shifts in population trends have multiple impacts on the environment, but their nature and effects are often misunderstood or oversimplified, leading to population dynamics being ignored in both intergovernmental negotiations and adaptation to these changes.

Demographic change, with its global megatrends of migration and population ageing, as well as numerous health issues, has significant implications for the transition to sustainability and challenges its human, technological, economic, social, and political elements. In discussions of mobility impacts, environmentally induced migration is sometimes viewed as a failure to adapt to environmental degradation that has resulted

in large numbers of displaced people. However, the reality is much more complex. An alternative view presents migration as an important adaptation strategy. Population ageing is thought to have a direct impact on the environment by leading to changes in consumption levels and patterns, resulting in a reduction in certain environmental pressures. The impact of an ageing population on labour markets, as well as the negative consequences for fiscal balances, can affect public and private budgets, which in turn can influence policy and discourage investment. Therefore, more accurate information is needed to dispel misconceptions (growth paranoia, Anthropocene, etc.) that often underlie the population-development nexus and to formulate policies that lead to a transition to sustainable societies.

**Keywords:** demography, population, sustainability



## **The European Cooperation in Science and Technology - opportunity for young researchers to strengthen their careers**

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**Abstract:** COST (European Cooperation in Science and Technology) is the oldest intergovernmental funding organization in Europe with the aim to establish the research networks among scientists and innovators. It has become one of the greatest mechanisms for promoting international scientific cooperation in recent decades, with a considerable influence on the careers of young researchers. Proximity is highly critical for establishing scientific collaboration, but once established, scientists may maintain collaboration even across long distances. Participating in a COST Action, in this sense, fosters closeness by allowing scientists from various nations, research fields, and industries to meet and thereby overcome conventional boundaries (Seeber *et al.* 2022a). A particular focus of COST network is to assist early-career investigators and young scientists in developing new skills by providing opportunities to get involved in Action activities such as training schools, short-term scientific missions, workshops, conferences, etc. (Mijić and Marinković, 2024). In this paper the impact of participating in a COST Action on the level of scientific production of researchers coming from less-research-intensive COST Member countries,

known as Inclusive Target Countries (ITC), will be presented. Some recent studies demonstrate a notable average increase in scientific co-publications among active action members, as well as interdisciplinary collaborations, and an increased involvement of early career researchers (Seeber *et al.* 2022b). COST Actions continue to have a favorable impact on young researchers' careers even after they are terminated. Participation in COST activities has become progressively competitive, with researchers from Serbia accounting for more than 90% of running Actions (Mijić and Marinković, 2022). To ensure effective participation in COST Actions, information on both new national and COST procedures will be provided and discussed, as well as an overview of currently available positions in running COST Actions.

**Keywords:** COST, Networking, Collaborative publications, Inclusive target countries

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# *POSTERS*

## Confined molecular systems and astrochemical modelling

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**Abstract:** In the past few decades, computational chemistry methods have grown in significance for studying the dynamics and interactions of small molecules encased in bigger structures (see Albert et al. 2020 and references therein). In constrained systems, molecular clouds play a crucial but little understood role despite their enormous size (Reis et al. 2022). Few hundred molecular species, including diatomic to massive anions, cations, and neutrals, are currently known to exist in interstellar space (see e.g. Roesky & Mandel 2010). Deep within molecular clouds, molecules can resist photodissociation and/or photoionization

due to the scattering and absorption of interstellar radiation (Vujčić et al. 2023, de Lara-Castells and Hauser 2020). Thus, it is imperative to study both collisional and radiative processes.

**Keywords:** Atomic and molecular data, Molecular ions, molecular clouds, Confined systems

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## Novel Research in Astrophysics and Geophysics

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**Abstract:** In the past few decades innovative approach is to foster collaboration and effective synergies among disciplines such as space exploration, atmospheric and Earth observations, laboratory and field experiments, and numerical modeling, with a high potential for direct application in Earth and other planetary research. Modeling various atmospheres with supercomputer capability, as well as diagnosing astrophysical and laboratory plasma using atomic and molecular datasets, relies on the creation and improvement of theoretical techniques and data computation methods (see e.g. Srećković et al. 2024). Multi-instrument and multi-disciplinary competence are needed to solve complicated climate concerns and its repercussions. Moreover, the growing amount of data suggests a rise in the use of automated tools and retrieval techniques (see e.g. Škoda and Adam 2020 and references therein). Model evaluation, data assimilation, satellite validation, and investigations of diverse

processes in the atmosphere and on Earth can all easily make use of the new information and retrieval products.

This contribution is progress report of work on a common topic within the bilateral project "The analysis of big data related to earth and sky observation: environmental applications and influence on life sciences" between the Bulgarian Academy of Sciences and the Serbian Academy of Sciences and Art.

**Keywords:** modeling, climate, multi-disciplinary investigation

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## Dataset for low ionosphere modeling

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**Abstract:** Strong radiation has the potential to alter the structure of the Earth's atmosphere by causing more ionization. These kinds of solar activity and radiation cause sudden ionospheric disturbances (SIDs), interfere with communications from space and electrical devices on Earth, and may cause a variety of natural disasters. This work focuses on the analysis of ionosphere plasmas and their properties, as well as the investigation of SIDs utilizing very low frequency (VLF) radio signals to forecast the impact of strong radiation on Earth. The daylight atmospheric characteristics caused by this severe radiation are obtained using the model computation, which is based on all data gathered by VLF BEL stations (see Srećković et al. 2021; Šulić et al. 2016). We offer a straightforward approximation formula for electron density and an empirical model of the D-region plasma density.

**Keywords:** modeling, climate, VLF

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## Monitoring and Analyzing Astronomical Transients in Real-Time

Veljko Vujčić<sup>1\*</sup>, Vladimir A. Srećković<sup>2\*</sup> and Radoslav Zamanov<sup>3</sup>

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**Abstract:** As LSST / Rubin survey is approaching its first light, it will produce a near real-time data stream {Juric et al. 2016} of variable astronomical objects, also called transient events - or colloquially 'alerts'. Information on astronomical objects can be combined from multiple active or passive data sources, legacy databases or "follow up" observations, predictive AI models or categorization and pattern matching. Based on our previous research {Vujčić & Jevremović 2020}, we update our review of various software tools used for working with real time astronomical data streams.

**Keywords:** astronomical transients, real time event processing, complex event processing

### Acknowledgement

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## **Modern society and climate change: oil and space industries perspectives**

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**Abstract:** Modern society is most often evaluated according to the presence and development stage of the space industry in a country on one hand and of the oil industry on the other. These two completely different industry branches are closely related in sense of prosperity and comfortable living style conditions of a population. However, fundamental differences between these two are most prominent in sense that space industry, primarily with infrastructure of space station and satellites, also including rocket probes and diverse space missions, is strongly influenced by and directly under space weather and space climate conditions as "external" factors, while oil industry, with its up-mid- and down-stream sectors and their infrastructures including all of the specificities and diversities, is directly impacted by social components as "internal" factors, with wide range of aspects, such as from e.g. war unstable regions of the Earth, across monetary and market trends to geopolitics. As the oil industry is most often and primarily recognized as the main culprit of accelerated and intensified climate changes, it is often forgotten that climate change is a natural phenomenon in the

geological evolution of the Earth. Although historically, oil industry with all related industries had indeed strongly impacted our living conditions, and in continual manners still does in sense of enormous pollution of all spheres of the Earth, including soil, water and air, space industry is often neglected as source of pollution even though produces massive pollutions primarily of the air and also of the soil at the place of launch in first place, but also in the space as well. As two sides of the same coin, global influences of these two industries on climate through pollution processes and related living conditions in modern societies are examined and analyzed, with main findings presented here.

**Keywords:** climate change, pollution, space industry, oil industry

## Modeling the atmosphere: various potentials

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**Abstract:** The desire to model diverse atmospheric plasmas ranging from medium to strong non-ideality prompted additional research of the optical features of such systems. This submission presents a more comprehensive set of results and properties for such systems. Our research methodology, as well as the existing and prospective applications, are outlined.

**Keywords:** modeling, potentials, multi-disciplinary investigation

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## **Influence of Solar Activity on Earth's Climate**

Predrag Jovanović<sup>1\*</sup>, Vesna Borka Jovanović<sup>2</sup>, Salvatore Capozziello<sup>3,4,5</sup>  
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**Abstract:** Here we reconsider some astrophysical, geophysical and meteorological indicators about the possible influence of solar activity on space and terrestrial weather. We used wavelet transforms to perform spectral analysis of several solar activity and geophysical data in order to detect their common oscillations, and to study the temporal stability and statistical significance of such oscillations. Besides, we also calculated the cross-correlation functions between the solar activity and geophysical time series. The obtained results indicate that solar activity may have a significant influence on weather on Earth by perturbing the global atmospheric circulations and geomagnetic field, as well as by affecting Earth's albedo and cloud formation.

Several possible physical mechanisms which explain that influence is also suggested.

**Keywords:** solar activity, Earth's climate, space weather, terrestrial weather

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## **SECTIONS (MINI PROJECTS)**

**M1** Multidisciplinary perspectives on climate and social connections

**M2** Geophysics and Astrophysics in the context of climate change

**M3** Understanding a sustainable environment through the prism of climate and transport linkages

**M4** Introduction to statistical software and machine learning

Tuesday, September 10 2024 (Day 1)		
Start	End	Session
15:00	15:30	Registration
15:30	16:00	Opening ceremony
16:00	16:30	<b>Magdalena Christova</b> TBD
16:30	18:30	<b>Round table</b> <i>Transdisciplinary Solutions for Climate and Community</i> <b><u>By invitation only</u></b>
18:30	20:00	Work on mini projects

<b>Wednesday, September 11 2024 (Day 2)</b>		
<b>Start</b>	<b>End</b>	<b>Session</b>
10:00	10:30	<b>Milan S. Dimitrijević</b> Pleanry Lecture <i>Nobel prizes for physics obtained for astronomical discoveries in XXI century</i>
10:30	11:00	<b>Milica Langović</b> Invited Lecture <i>Environmental migration in the Balkans: Contemporary trends</i>
11:00	11:30	<b>Milica Langović</b> <i>Linkages between internal displacement and climate: Evidence from Serbia</i>
11:30	12:00	Coffee break
12:00	12:30	<b>Zoran Mijić</b> <i>The European Cooperation in Science and Technology - opportunity for young researchers to strengthen their careers</i>
12:30	13:00	<b>Danica Šantić</b> <i>Is demography a real problem for sustainability?</i>
13:00	13:30	<b>Felix Iacob</b> TBD
13:30	15:00	Lunch break
15:00	18:00	Work on mini projects
18:00	20:00	Welcome cocktail

<b>Thursday, September 12 2024 (Day 3)</b>		
<b>Start</b>	<b>End</b>	<b>Session</b>
10:00	10:30	<b>Milan S. Dimitrijević</b> Plenary Lecture <i>Milutin Milanković and climate changes - Ice ages secret</i>
10:30	11:00	<b>Nikola Veselinović</b> Invited Lecture <i>Cosmic rays as a clock (or Using cosmic rays for imaging and to study past)</i>
11:00	11:30	<b>Mihailo Savić</b> Invited Lecture <i>Cosmic Rays and Their Connection to Space Weather and Earth's Climate</i>
11:30	12:00	Coffee break
12:00	12:30	<b>Aleksandra Kolarski</b> <i>VLF radio signal propagation under severe stormy weather conditions</i>
12:30	13:00	<b>Filip Arnaut</b> Invited Lecture <i>Analysis of possible relationship of between earthquakes and Solar flare events during Solar cycle 24</i>
13:00	13:30	<b>Filip Arnaut</b> <i>Solar Wind and Seismic Activity in the Balkan Peninsula: a 2019- 2023 Progress Report</i>
13:30	15:00	Lunch break
15:00	18:00	Work on mini projects
18:00	19:00	Poster session
20:00	23:00	Conference dinner

<b>Friday, September 13 2024 (Day 4)</b>		
<b>Start</b>	<b>End</b>	<b>Session</b>
10:00	10:30	<b>Nikolina Pop</b> <i>From Solar energy to molecular energetics</i>
10:30	11:00	<b>Vladimir Nestorović</b> <i>Traffic accidents in winter conditions for the Republic of Serbia</i>
11:00	11:30	<b>Sreten Jevremović</b> Invited Lecture <i>Weather conditions influence on traffic crashes in the Republic of Serbia</i>
11:30	12:00	Coffee break
12:00	12:30	<b>Aleksandar Medarević</b> Invited Lecture <i>Active Transport: A Pathway to Greener Planet, Healthier and Happier Lives</i>
12:30	13:30	Work on mini projects
13:30	15:00	Lunch break
15:00	18:00	Mini excursion

Saturday, September 14 2024 (Day 5)		
Start	End	Session
10:00	11:00	Organizing committee meeting
11:00	11:20	Closing ceremony
11:30		Departure for Belgrade



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