Back-to-Back Summer July Heatwaves Reveal the Fingerprint of Human-Caused Climate Change

Findings from Faculty of Physics, University of Belgrade

Belgrade, 2025

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In late July 2025, Southeastern Europe, together with southern Italy and Sicily, experienced a severe heatwave ranking among the top 10% most intense since 1950 in most countries of the region, particularly across the Balkan area. The pronounced heatwaves throughout July contributed to wildfires in these regions, as well as multiple official warnings about extreme heat, which has increasingly become an extraordinary public health concern.

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1. INTRODUCTION: WHAT HAPPENED IN JULY 2025?

In late July 2025, Southeastern Europe, particularly the Eastern Mediterranean, endured an intense heatwave, with temperatures soaring above 42–44°C. In Silopi, southeastern Turkey, authorities reported an unprecedented 50.5°C, the highest temperature ever recorded in the country.

Although temperatures in Serbia and the wider region did not reach such temperatures, they were exceptionally unusual for our climate, averaging 8–10°C above the normal from 1961–1990. According to Serbia's national meteorological service (RHMSS), July 2025 ranked as the country's fifth hottest July on record. The month saw two major heatwaves, with the late-July event pushing temperatures above 40°C in many areas, including 44°C in Kruševac and 42°C in Banatski Karlovac, where absolute daily records were broken.

During the second half of July 2025, Serbia experienced an intensive heatwave that lasted from 20 to 26 July. Heatwaves can be defined in different ways, but in this report, for determining their length, they are identified as periods when daily maximum temperatures are above the 90th percentile of values calculated for the reference period 1961–1990.

Compared to this baseline, temperature anomalies during the event reached 8–9 °C above average, making it one of the most extreme heat episodes in recent decades. The southern and eastern regions of the country were particularly affected.

The heatwaves also brought pronounced tropical nights, when minimum temperatures remained above 20°C, adding significant cumulative stress to human health on top of the extreme daytime heat. In Belgrade, a city with pronounced urban heat island effect, nighttime temperatures between the 25th and 26th of July stayed above 25C.

Beyond posing a severe public health risk, these extreme temperatures strained water supplies, disrupted agricultural production, pressured the energy sector, and heightened the risk of wildfires across the region. Prolonged and more frequent summer heatwaves dry out soil and vegetation, creating conditions that easily trigger wildfires.

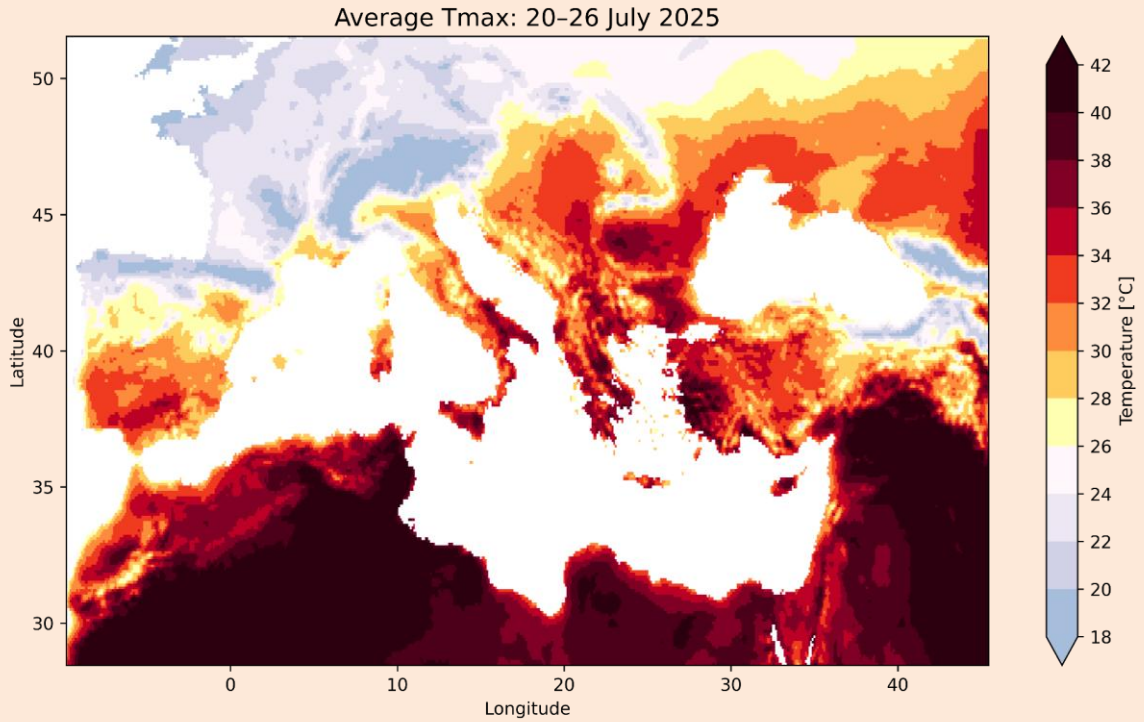

Figure 1 - Average maximum daily temperature for the period 20-26.07.2025

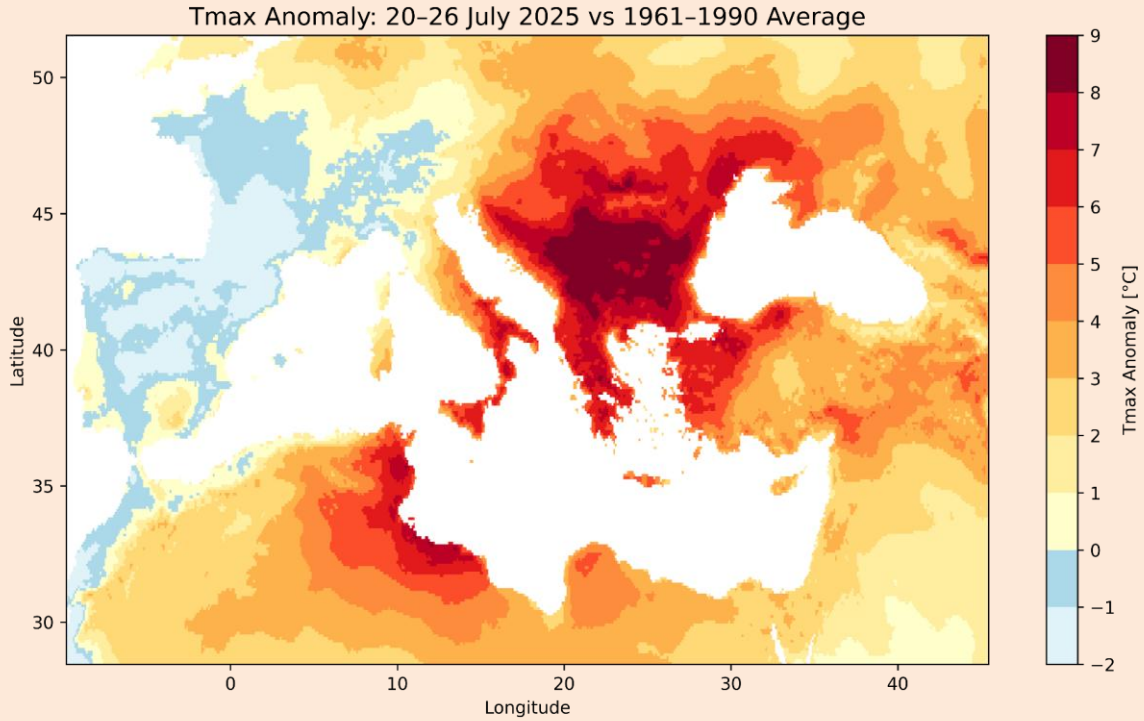

Figure 2 - Anomalies of maximum daily temperature compared to the reference period from 1961-1990, for the period 20-26.07.2025

2. HOW UNUSUAL WAS IT?

When an extreme weather event like this heatwave occurs, a common question arises: *is climate change to blame?* For many years, scientists could only answer in general terms, saying that as the planet warms, extreme events are expected to become more frequent and severe. Today, however, thanks to advances in attribution science, we are able to provide much more detailed answers.

In 2014, World Weather Attribution (WWA) was founded, a scientific initiative that works with researchers worldwide to quantify how climate change influences the likelihood and intensity of specific extreme weather events. Using a combination of weather observations and climate models, WWA studies are carried out rapidly, often within days or weeks of an event, to provide timely insights. With the support of the European Climate Foundation, our goal is to better understand how climate change is shaping the intensity and likelihood of such events in South East Europe.

The heatwave of 20–26 July 2025 was not the longest on record, but it brought exceptionally high temperatures, especially in the southern and eastern parts of Serbia, where absolute temperature records were broken. To identify extreme heatwaves, we looked at a 3-day rolling average of daily maximum temperatures and took the highest value for June and July. This heatwave ranks as the 4th most severe in the historical record we analyzed.

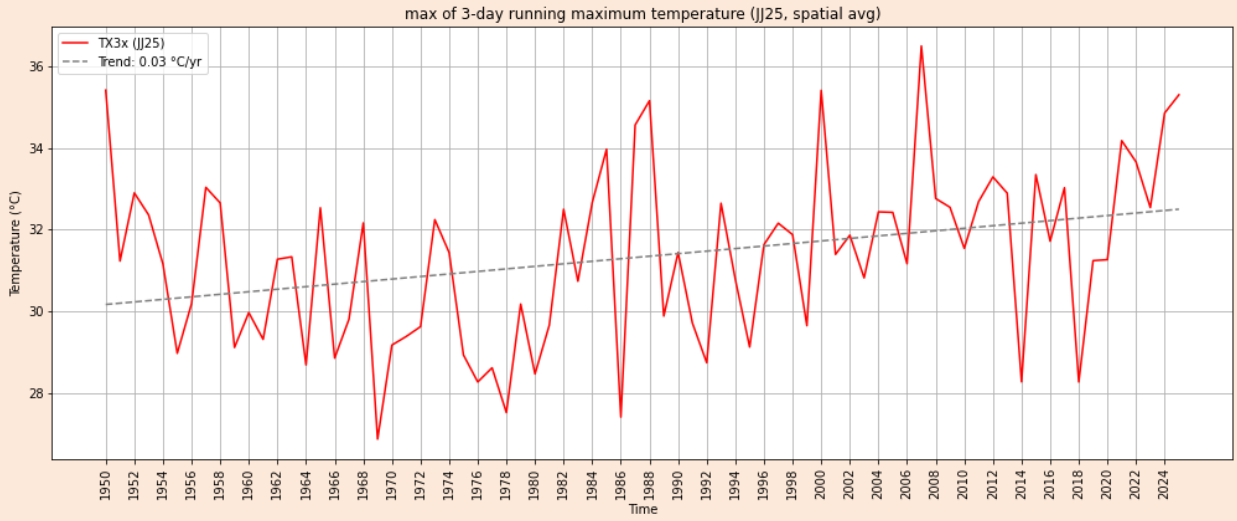

Figure 3 - Highest values of maximum daily temperatures averaged over 3 days during June and July, with a trend line.

Looking at trends over the last decades, extreme heatwaves are becoming more frequent. Between 2020 and 2025, Serbia experienced 7 extreme heatwaves, compared with 3 in 2010–2019, 4 in 2000–2009, and only 1 in 1980–1999. Earlier decades had very few, with just 2 recorded in the 1950s.

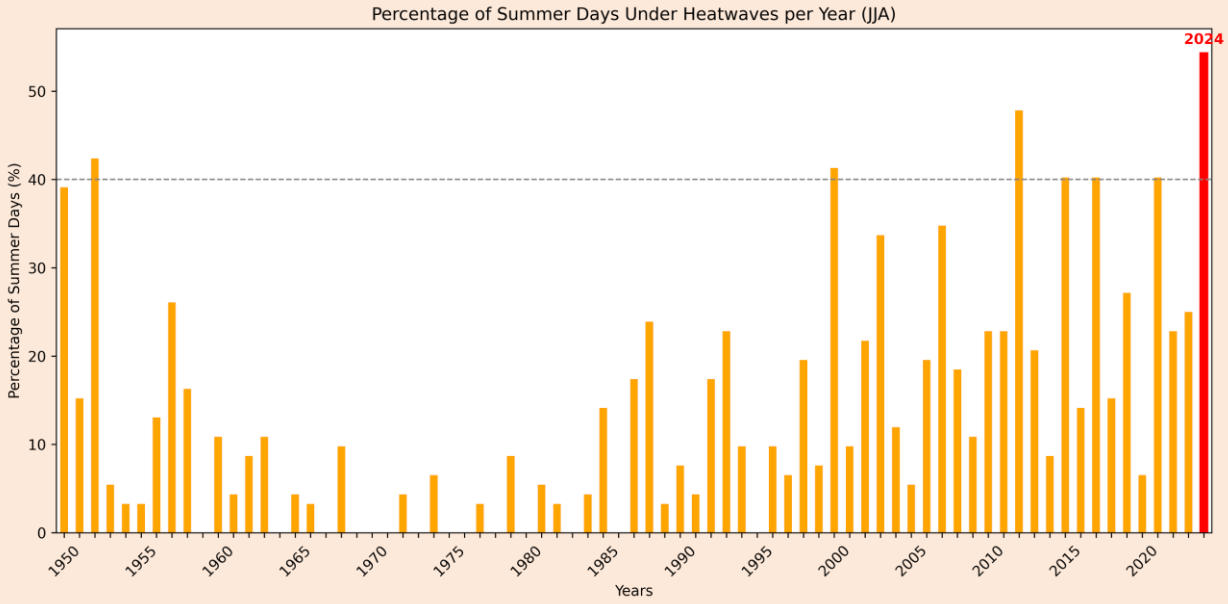

Figure 4 - Percentage of summer days (months June, July and August) affected by heat waves

3. WHAT WAS THE ROLE OF CLIMATE CHANGE?

Typically, WWA compares the current climate to a pre-industrial climate. However, because reliable observational data before 1950 are not available in our dataset (we used the reanalysis dataset ERA5-Land), we compared the heatwave events in a constructed climate of 2024 to a corresponding to the conditions in 1950.

Using this approach, we look at how the temperature thresholds that define heatwaves have shifted over time, taking into account how they correlate to global warming trends, i.e. trend in global mean surface temperature anomaly. This allows us to estimate how much more likely or intense heatwaves are today compared to the mid-20th century, even without going back to pre-industrial conditions.

Our analysis shows that the July 2025 heatwave would have been extremely unlikely in the climate of 1950. Based on observational data, the probability of such an event occurring today is almost 12 times higher than it was in 1950. In other words, what was once a very rare event has become much more common.

We can also look at this in terms of the “return period,” which tells us how rare an event of this strength is. In the 1950 climate, a heatwave like this was extraordinarily rare, roughly comparable to what might happen once in 65 years. Today, under the 2024 climate, a heatwave of similar intensity is far less unusual, roughly once in every 5-6 years on average. This doesn’t mean it will happen exactly on schedule, but it gives a sense of how the odds have increased.

These findings clearly illustrate the growing influence of climate change on extreme heat. Heatwaves that were once exceptional are now becoming far more frequent, posing increasing risks to people, infrastructure, and ecosystems.

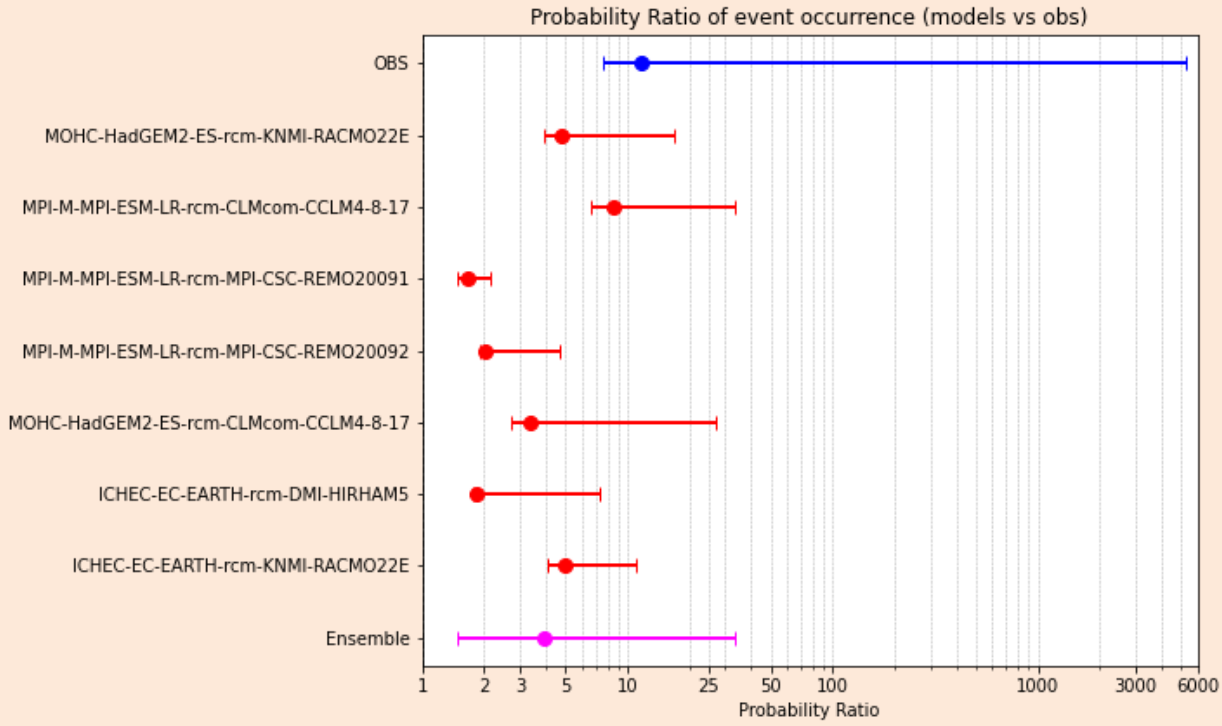

Figure 5 - Probability ratios of the July 2025 heat wave in the modern climate and the mid-20th century climate. Results are calculated from observations (blue), models (red) and model ensemble (magenta)

The horizontal lines show the "probability ratio" — how many times more likely the event is today. The dots are the best estimate, and the lines show the uncertainty. A value of 1 would mean "no change." Anything above 1 means the event is more likely because of climate change.

All the models (red), as well as the observations (blue), agree that the probability ratio is well above 1. The numbers vary across models — some say it's a few times more likely, others hundreds or even thousands of times — but the direction is the same: climate change made this event more likely. The magenta "ensemble" result combines all models and gives an overall picture, again showing a clear increase.

4. COMPARISON WITH THE JULY 2024 HEATWAVE

The main difference between the 2024 and 2025 events lies in the fact that the 2025 event was considerably shorter but with more extreme values, with the hardest-hit area being the south and southeast of the country. The summer of 2024 was a culmination of a series of record-breaking hot months. The summer was characterized by long extremely hot episodes which is reflected by the data. Considering the three-day averaged maximum daily temperature as the heatwave metric, the probability ratio of the 35.51℃ event is 10.79 in

2024, compared to the 35.30℃ event with the probability ratio of 11.75 for 2025. This suggests that the 2025 heatwave was rarer, because it occurred during an uncharacteristic part of the year. The intensity of the 2024 heatwave is reinforced when considering a running average over a longer period of time, with the event of 31.73℃ being obtained using the 20-day running average having a probability ratio of 19.39 which would suggest that longer lasting events are becoming more frequent. While the average temperature is lower than for a shorter event, prolonged exposure to high levels of heat stress are far more dangerous than shorter periods of extreme stress.

5. CREDITS & CONCLUSIONS

The study was conducted using data from the ERA5-Land reanalysis and following the methodology used by the international World Weather Attribution (WWA) initiative. Although reliable data for the pre-industrial period are lacking, comparing heat wave events in a constructed climate from 2024 with a climate corresponding to 1950 conditions provides a clear picture of how much more frequent such extremes are today.

The research was conducted by a group of scientists from the University of Belgrade, Faculty of Physics, through a project supported by the European Climate Foundation (ECF). Through this project, researchers are improving their skills by applying different methods for climate attribution of extreme events, including the World Weather Attribution (WWA) methodology. Together with colleagues from Romania, Hungary and Greece, they are working on the application of the WWA methodology and conducting research that is one of the first of its kind in Southeast Europe. They are also the first team of scientists in the region to practically apply this method, and the project will establish a system that will, in the event of extreme events in the future, enable appropriate attribution studies in a short period of time after the event itself.

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