

The Mediterranean in the Face of the Climate Emergency and the Increase in Extreme Weather Events

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It is unequivocal that human influence, mainly emissions of greenhouse gases, has warmed Earth's atmosphere, ocean and land. This recent and accelerated warming cannot be explained by natural drivers such as solar activity, volcanic eruptions or internal climate variability. For example, the year 2023 is confirmed as Earth's warmest year since modern record-keeping began around 1880, and the past 10 consecutive years have been the warmest 10 on record.¹ The broader Mediterranean region is also significantly impacted by global warming. It is considered by scientists a prominent climate change hot spot that warms faster than the global average rates and faster than many other inhabited parts of the world (Cramer et al., 2018; Zittis et al., 2022). During the past four decades, the warming rates have exceeded 0.4°C/decade. Besides anthropogenic greenhouse gases, which is by far the dominant cause, the enhanced warming is caused by regional drivers, such as drying soils, and enhanced radiative forcing from declining aerosols, including anthropogenic pollutants and natural sources (Urdiales-Flores et al., 2023). Concerning rainfall, the trends are more variant, and their direction, magnitude and level of significance can vary depending on the location, season or period of assessment (Cherif et al., 2020). The latest Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) reveals a robust increase in the frequency and intensity of heat ex-

tremes globally. The report also reveals a strong belief that humans have contributed to these observed changes in many regions, including the Mediterranean. In recent years, there have been several instances of record-breaking temperatures in various Mediterranean locations. For instance, Sardinia in Italy recorded 47.3 °C in July 2019, Nicosia in Cyprus recorded 46.2 °C in September 2020, Cordoba in Spain recorded 47.6 °C in August 2021 and Sicily in Italy recorded 48.8 °C in August 2021.

Agricultural and ecological droughts in our region have also increased in recent times. For example, recent mega-droughts in the eastern Mediterranean and the Levant have drawn considerable attention, while their magnitude cannot be fully explained by natural climate variability alone (Cook et al., 2016; Kelley et al., 2015). Another recent example is the 2022 Po River drought in Italy, which was the worst hydrological drought event of the last 200 years (Montanari et al., 2023). In terms of river flow, it was 30% lower than the second worst case, with such events expected to occur once every six centuries. Extraordinary measures were taken to support farmers, as the Po Valley supplies around 40% of the country's food demand. In addition, the drought also affected the productivity of both hydropower and thermoelectric stations.

At the other extreme, despite the occurrence of heavy rainfall episodes, many of them associated with a high number of fatalities, destruction of critical infrastructure and enormous financial losses, historical trends of such events are less certain, and attributing them to anthropogenic climate change is not as straightforward as it is for heat extremes or droughts. In September 2023, Storm Daniel deposited >1,000mm of

¹ www.nasa.gov/news-release/nasa-analysis-confirms-2023-as-warmest-year-on-record/.

rainfall in Thessaly, Greece, over a 24-hour period (Fowler et al., 2024). This is almost the same amount the area typically receives in one year. The same Mediterranean cyclone struck eastern Libya on 10 and 11 September 2023. About 25% of the Libyan port city of Derna was destroyed by a massive torrent of water and mud after two dams located upstream from the city collapsed from pressure brought on by the heavy rains, resulting in more than 4,000 fatalities.²

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The future of the Mediterranean climate and environment strongly depends on the emission pathways that we adopt. Complying with the Paris Agreement’s main targets,³ i.e., keeping global warming to well below 2°C above pre-industrial levels, implies a stabilization of regional warming within the coming two to three decades, less disruptive changes in the hydrological cycle and a wider time window for societies and ecosystems to adapt (Cherif et al., 2020; Zittis et al., 2019). On the contrary, projections based on “non-action” or “business-as-usual” pathways point to a more pessimistic future where regional warming can exceed 6°C with respect to the pre-industrial era, parts of the Mediterranean will become even drier and mean sea levels will also continue to rise. In such a scenario, the Mediterranean warming will be more pronounced during the summers, leading to the occurrence of heatwaves of unprecedented duration and intensity (Zittis, Hadjinicolaou, et al., 2021). Water resources will be further challenged by more frequent and intense droughts (Spinoni et al., 2021). Although the trends of ex-

treme rainfall events are less robust, individual cases are again expected to augment (Zittis, Bruggeman, et al., 2021). Such types of weather-related hazards will impact virtually every socioeconomic activity in the Mediterranean (Hochman et al., 2021).

Exposure to heat poses a major threat to high-risk populations in Europe and worldwide by substantially contributing to increased morbidity and mortality (Ballester et al., 2023). In terms of extreme weather events, heat waves have the highest impact in terms of attributable counts of death. In the Mediterranean, the number of days with high heat risk is projected to increase dramatically (Casanueva et al., 2020). This is also the case for productivity losses due to environmental heat exposure. High temperature and humidity can cause discomfort not only to permanent residents but also to tourists and visitors (León et al., 2021). Mediterranean summers in the future may become too hot for visitors, while regions in northern climate zones might become more attractive.

The compound effect of droughts and heat waves could lead to a significant rise in the demand for both water and energy. Water is not only required for domestic use but also for irrigation of the already strained Mediterranean farmlands. Due to the increased summer temperatures, a considerable amount of energy is needed for space cooling and air conditioning. Additionally, desalination plants that are heavily utilized during the hot and dry Mediterranean summers also consume a substantial amount of energy.

A rise in temperature and aridity due to climate change can create a conducive environment for forest fires by providing ample fuel material

Agriculture and ecosystems are both negatively impacted by changing climate conditions and the occurrence of more frequent or extreme weather events. Rain-fed grazing lands or crops such as olives, barley and wheat, widespread in the Mediterranean, are highly susceptible to environmental and climate changes

² www.britannica.com/event/Libya-flooding-of-2023.

³ <https://unfccc.int/process-and-meetings/the-paris-agreement>.

(Al-Bakri et al., 2011; Kitsara et al., 2021; Papadaskalopoulou et al., 2020; Rodrigo-Comino et al., 2021). An increase in aridity and drought frequency is estimated for most Mediterranean regions, impacting vegetation yields (Constantinidou et al., 2016; Daliakopoulos et al., 2017). Extended periods of extremely high temperatures during the spring or summer months can also cause crops to fail. Additionally, “false springs” which occur during late winter or early spring, when the weather is warm enough to trick vegetation into awakening from dormancy prematurely, can lead to plant losses due to subsequent low temperatures at the start of the vegetation-growing season. Such events in the Mediterranean are expected to become more frequent under a warmer climate (Olschewski et al., 2024). In such cases, food security and prices will be less certain, and a higher dependence on food imports is expected.

Forest fires have become more widespread in the Mediterranean. Last summer’s fires in Rhodes, Greece,⁴ and Tenerife, Spain⁵ are recent examples of how climate conditions, e.g., long spells of extreme heat and dryness, can favour the expansion of forest fires regardless of the ignition causes, which are mostly negligence or malicious actions by humans. A rise in temperature and aridity due to climate change can create a conducive environment for forest fires by providing ample fuel material. This can pose a greater risk of wildfires in the future, particularly in Mediterranean forests adjacent to semi-arid environments.

Ecosystems in the Mediterranean biodiversity hot spot provide a range of services including the provision of food or materials, regulating services, such as moderation of extreme events, carbon sequestration or pollination, cultural or recreational experiences and more. Thus, they can be considered cost-effective, nature-based solutions for climate mitigation and adaptation (Vogiatzakis et al., 2023), although, they are frequently overlooked by stakeholders or scientists. Unfortunately, Ecosystem Services are significantly impacted by climatic and non-climatic drivers, such as pollution, uncontrolled development and extensive changes in land use.

The expected climate change impacts, briefly discussed here, also depend on socioeconomic and demographic factors that determine, for example, the

level of exposure to extreme weather events. For instance, strong urbanization is observed in the region, a trend expected to continue in the future. Moreover, the capacity to adapt also depends on the available financial resources, technological means, transnational relationships and willingness for transformational changes. In the Mediterranean region, there is a high diversity in these aspects, especially in the southern and eastern states, which, amongst other challenges, are disturbed by financial and political instability, often leading to competition for resources and conflicts.

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Climate change can act as a threat multiplier and increase the intensity or occurrence of natural disasters. However, it’s important to note that human decisions and poor governance also play a leading role in how we address such challenges. Examples of mismanagement, bureaucratic procedures, inefficient resource allocation, lack of proactiveness and timely planning or inadequate transnational collaboration exist in many countries of the region. To tackle the impacts of climate change and ensure the well-being and prosperity of Mediterranean societies, it is essential to increase preparedness, develop and implement adaptation strategies, promote research, adopt innovative and sustainable solutions and foster international collaboration and solidarity.

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⁴ www.bbc.com/news/world-europe-66295972.

⁵ <https://edition.cnn.com/2023/08/17/europe/spain-tenerife-wildfire-evacuations-intl/index.html>.

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