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Research Highlight

'Analysis of the 2024 Hajj heat event and future temperature extremes in Mecca'

Summary

Extreme heat events in the Middle East have become increasingly frequent and intense due to human-driven climate change. During the Hajj pilgrimage in Mecca, Saudi Arabia, in June 2024, temperatures soared to a record-breaking 51.8 °C, resulting in the tragic deaths of at least 1300 pilgrims and over 2700 non-fatal injuries. Considering that the intensity and persistence of this heatwave exceed all recorded analogues in the available historical record, it may be considered statistically unprecedented within the context of the observed climate. Our analysis suggests that the exceptional event of June 2024 represents typical extreme conditions towards the second half of the century if current trends continue. The record-breaking temperature of nearly 52 °C illustrates the potential threats climate change could pose to major outdoor gatherings, such as the Hajj pilgrimage, under business-as-usual scenarios. Addressing these challenges through effective climate mitigation and adaptation is essential to building resilience against future extreme heat risks.

Impact

Understanding historical and future heat extremes is essential for sustained adaptation. In this context, recommended measures should evolve with climatic trends through regular reassessments, technological upgrades, and alignment with long-term projections. The uniquely harsh desert environment of Mecca may serve as an important testbed for adapting to future climate conditions that other regions may increasingly encounter as global temperatures rise. While mitigation measures and technological advancements can moderate impacts, several challenges remain and are likely to worsen as greenhouse gas concentrations continue to rise. This is relevant for outdoor labor activities or cultural and religious events, such as the Hajj, especially when they occur during the hottest months. To effectively assess and address the impacts of climate change in a region characterized by extreme environmental conditions, limited resources and

Authors' bios

Dr George Zittis is a Research Scientist at the Climate and Atmosphere Research Center (CARE-C) of the Cyprus Institute, where he leads the Climate Change Downscaling & Extremes Research Group. Since 2025 he is the Chair of the MedCLIVAR scientific network. He contributes to MedECC and other international initiatives and research projects about climate change and its impacts on the broader Mediterranean and Middle East region.

diverse cultural backgrounds, it is essential to raise awareness and enhance research and dissemination.

Reference

Zittis G., Alberti T., Almazroui M., Driouech F., Faranda D., Francis D., Hadjinicolaou P., Kurnaz L., Lazoglou G., Nikulin G., Osipov S., Ozturk T., Stenchikov G., Tanarhte M., Zaaboul R., Lelieveld J. (2025) Analysis of the 2024 Hajj heat event and future temperature extremes in Mecca. npj Natural Hazards, 2, 107. https://doi.org/10.1038/s44304-025-00159-3

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