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The June 2024 Middle East compound heatwave: Dynamical drivers and AI-weather forecast models' evaluation

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Heatwaves are intensifying across the Middle East with distinct daytime and nighttime impacts. We quantify the climatology and trends of daytime, nighttime, and compound heatwaves using station observations for 2005 to 2025, and evaluate four AI-weather models for near-surface air temperature during a recent high-impact episode (Zittis et al., 2025).

Daytime heatwaves recur from the eastern Mediterranean through northern Iraq and Iran into Anatolia during warm seasons, whereas nighttime and compound events cluster along the southern Red Sea and Arabian Gulf coasts. Trends show significant summer and autumn increases across all classes (daytime: +4.09 and +6.09; nighttime: +4.13 and +6.22; compound: +3.42 and +2.40 per year), a winter increase led by nighttime events, and a spring increase in both nighttime and compound events, consistent with asymmetric diurnal warming, strong land–atmosphere coupling over arid interiors, and coastal humidity that limits nocturnal cooling.

A case study of 10 to 27 June 2024 documents record-breaking daytime anomalies over the northern Middle East and persistent nocturnal warmth along maritime margins, with peak impacts around 17 June in the Mecca region. ERA-5 diagnostics indicate a quasi-stationary Rossby wavetrain, an anomalous ridge over southwest Asia, and an intensified Arabian Heat Low that weakened low-level ventilation and sustained humid coastal nights.

We assess GraphCast, PanguWeather, FourCastNetv2, and Aurora using six-hourly forecasts initialized at 00 UTC on 12 June 2024 and verified against ERA-5 from 12 to 22 June. All capture synoptic timing and multi-day persistence but underestimate daytime peaks and show lead-dependent cold biases. PanguWeather provides the strongest deterministic temperature guidance; GraphCast corroborates synoptic evolution. Operationally, a bias-corrected PanguWeather and GraphCast blend is recommended.

Reference:

Zittis, G., Alberti, T., Almazroui, M. et al. Analysis of the 2024 Hajj heat event and future

temperature extremes in Mecca. npj Nat. Hazards 2, 107 (2025). https://doi.org/10.1038/s44304-025-00159-3