

Amplified Seasonal Amplitudes and Delayed Summer Peaks in Arabian-Oman Gulfs Sea Surface Temperatures: Insights from ERA5 Reanalysis Observations (1940–2025)

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The Arabian Gulf and Gulf of Oman has emerged as one of the most rapidly warming marine regions globally, where elevated sea surface temperatures (SSTs) increasingly influence atmospheric instability, moisture transport, and the occurrence of severe rainfall events. In recent years, the region has experienced intensified rainstorms that have led to widespread flooding, infrastructure damage, and significant socioeconomic disruption, underscoring the urgent need to understand ocean–atmosphere interactions in the region.

This study investigates long-term SST variability and seasonal amplitude amplification along the Arabian Gulf and Gulf of Oman using monthly ERA5 reanalysis data from 1940 to 2025. A detailed spatiotemporal analysis was conducted along a ~1672 km profile to capture spatial heterogeneity in thermal behaviour. Time series decomposition was applied to separate trend and seasonal components, while seasonal variability was modeled using first-order Fourier series.

The results reveal a pronounced amplification of seasonal SST variability across the Arabian Gulf, with seasonal amplitudes reaching up to ~1 °C at several locations of the Arabian Gulf area. This substantial warming–cooling contrast indicates increasingly extreme thermal conditions that enhance evaporation and atmospheric moisture availability, creating favourable conditions for intense convective rainfall. In addition, the analysis reveals a clear phase shift in the seasonal SST cycle across different epochs. A phase shift of approximately 28 days (~1 month) is observed when comparing the early period (1940–1959) with more recent decades (1960–1979, 1980–1999, and 2000–2025). This shift indicates that peak sea surface temperatures now occur predominantly in August, whereas during 1940–1959 the seasonal maximum was observed in July. This temporal displacement suggests a systematic alteration in the seasonal timing of ocean thermal extremes in the Arabian Gulf.

These findings demonstrate a pronounced amplification of seasonal SST variability at several locations across the Arabian Gulf, together with a systematic phase shift of approximately one month in the timing of the peak temperatures over the recent decades. This combined intensification and temporal displacement of seasonal extremes indicates measurable alterations in the region. Such changes likely contribute to enhanced ocean–atmosphere interactions, with direct implications for severe rainfall events, urban resilience, infrastructure planning, water management, and regional socioeconomic stability. The study provides new quantitative evidence supporting the integration of SST- driven risks into climate adaptations and disaster preparedness strategies in this data scarce region.

Keywords: Sea surface temperature, Seasonal amplitudes, ERA5 reanalysis, Arabian Gulf, Gulf of Oman