

Response to Reviewer #2

Please note that the reviewer's comments are shown in *blue*, while our responses are shown in *red*.

RC2: 'Comment on egusphere-2025-2948', Anonymous Referee #2, 03 Sep 2025

The manuscript by Lachkar et al. addresses an important and timely topic by discussing the drivers of extreme summer sea surface temperatures in the Arabian Gulf. The authors combine an eddy-resolving ocean hindcast with ERA5 reanalysis, providing a framework to separate local and remote atmospheric influences. The work is well-motivated, as the Gulf is a critical hotspot of marine heat stress, with major ecological and socio-economic consequences. The manuscript is generally well-structured, the figures are clear, and the results are presented in a way that advances understanding of both local mechanisms (heat fluxes, Shamal winds) and large-scale teleconnections (ENSO, NAO). The finding that ENSO and NAO together explain over 50% of Gulf SST variability is particularly noteworthy and of interest for predictability. Overall, the paper makes a valuable contribution and is suitable for publication after some clarifications and refinements.

We sincerely thank the reviewer for their positive and encouraging feedback, and for the time and effort they invested in reviewing our manuscript.

Specific Comments

1) The current manuscript however distinguishes itself from earlier studies by focusing on summer SST extremes and their mechanistic links to atmospheric circulation, but the introduction could better highlight how this work fills the gap left by earlier Gulf studies that relied on multi-seasonal or coarser analyses. Also, how the Arabian gulf understanding can be important for precipitation extreme changes having said that arabian gulf as one of the moisture source for heavy rainfall (can be seen in Pathak et al. 2025).

Pathak, R., Dasari, H.P., Ashok, K. *et al.* Dynamics of intensification of extreme precipitation events over the Arabian Peninsula derived from CMIP6 simulations. *npj Clim Atmos Sci* 8, 126 (2025).
<https://doi.org/10.1038/s41612-025-01016-w>

Following the referee's recommendation, we will include a reference highlighting the relevance of Gulf summer SST to extreme precipitation events in the region, given the role of the Gulf as a key

source of atmospheric moisture. We will also more clearly emphasize how the present study addresses gaps in earlier Gulf studies that relied on multi-seasonal data and coarser analyses.

2) It is interesting to see that ENSO and NAO act largely independently and additively is interesting. Would be interesting to have a discussion expanded to compare with other ocean basins, where ENSO–NAO interactions are sometimes nonlinear.

While the interactions among different climate variability modes are complex and influenced by many factors, thus extending beyond the scope of the current study, a brief discussion of this aspect will be added to the revised manuscript. In particular, we will cite Folland et al. (2009), who report a weak correlation between La Niña and negative summer NAO, but no significant correlation between positive NAO and El Niño.

3) At LN170 and other places. The analysis finds a weak role for IOD and ISM. Given that the IOD is often invoked in regional SST variability, it would be helpful to provide a more explicit explanation of why its influence is muted in the Gulf, possibly due to the strong dominance of atmospheric fluxes over advective processes.

We thank the reviewer for this observation. As noted by the referee (and discussed in our response to Reviewer 1's comment #4), interannual variability in summer Gulf SSTs is primarily driven by variability in atmospheric fluxes, with only a modest contribution from lateral ocean advection from the Arabian Sea. Although Arabian Sea SST variability is influenced by the IOD and ISM, the propagation of this signal from the western Arabian Sea through the Strait of Hormuz into the Gulf has a limited impact on Gulf summer SSTs. This explains why the effects of all major climate modes, including ENSO and NAO, on SSTs in the Gulf and the Arabian Sea are either weakly correlated or even strongly anticorrelated (see Figure 13). This point will be more clearly highlighted in the revised manuscript.

4) Please provide a schematic summarizing the coupled processes (weakening Shamal winds, enhanced subsidence, moisture build-up), and the same would be very useful for readers.

Such a schematic (Fig. 14) was already included in the revised manuscript, but it was previously only referenced in the Conclusion, which we recognize may not be the most appropriate location.

Therefore, in the revised manuscript, we will refer to the figure earlier, at the end of the Results section, to increase its visibility.

5) Since as we know that ENSO and NAO are routinely monitored, please provide lead time with which Gulf summer SST anomalies could be anticipated.

As discussed in Section 4.4, there is potential for seasonal forecasting of summer Gulf SSTs with a 2–3 month lead time when initialized in late spring (e.g., May), particularly once the spring predictability barrier of ENSO (March–May) subsides and the skill of summer NAO prediction improves (Dunstone et al., 2023). We will clarify this point further in the revised manuscript.