Response to Reviewer comments

Dear Reviewer, thank you for taking the time to review our manuscript. We would also like to thank you for your comments and suggestions, which have helped us revise the manuscript into a better version. We understand that you have minor comments regarding discussions of some important relevant issues. We have revised the manuscript following your comments and suggestions. We hope the reviewer finds the manuscript meets the publication standards of WCD.

Reviewer comment #1 Lines 133 to 135 - Why is the two day average taken? There needs to be a discussion/ reasoning given for the same.

Author Response: Thank you for the comment. Since the statements in Lines 133–135 describe Figure 3, we understand that the reviewer, by saying "two-day average", is asking about the 2-day lag. We thank the reviewer for this comment. Following the reviewer's suggestion, we have revised the relevant section of the manuscript to improve the clarity of the narration. Lines 134-148 of the revised manuscript in track-changes format:

> Figure 3 depicts anomalous composite fields for early-onset years compared to late-onset years of observed SST (top panels), rainfall (middle panels), and 850hPa winds and convergence (bottom panels). The SST and wind data are from OISST and NCEP, respectively, while rainfall is from TRMM (1998-2019). The early-onset composites are based on 10 cases (7 cases for rainfall due to limited availability of TRMM data), and the late-onset composites are based on 12 cases (7 cases for rainfall). The SST fields are averaged over 10-15 days, 5-10 days, and 1-5 days. The atmosphere over the warm SST of the BoB responds with a local enhancement of rainfall (Goswami et al. 2021). We included a 2-day delay in the precipitation response to SST anomalies to account for some lag in the precipitation response (Roxy 2014, Xi et al. 2015). For

example, precipitation fields are shown for an average over 13 to 10 days before monsoon onset, corresponding to SST anomalies averaged over 15 to 10 days before monsoon onset, counting the monsoon onset day as day 0. The circulation responses are shown for the same durations as precipitation. Analyzing low-level jet strength over the Arabian Sea, Joseph and Sijikumar (2004) reported that LLJ strength over the Arabian Sea peaks 2-3 days after convection peaks over the BoB. This 2-3-day lag in the peaking of LLJ strength over the Arabian Sea in response to convection over the BoB indicates that the local circulation responds to atmospheric heating almost instantaneously. We performed this exercise for different lead times but show the results in Figure 3 since they are sufficient to emphasize the main features of the sequence of events we discuss. We note positive rainfall anomalies in the Arabian Sea off the western coast of India, but they are not persistent and are not investigated further.

We hope the reviewer is convinced. Thank you.

Reviewer comment #2. The authors mentioned that the IMD onset dates are based on synoptic changes but TT gradient represents large scale monsoon circulation - what is the difference in the onset dates wrt IMD data and TT gradient criteria and what changes are seen in the SST anomalies? It would be interesting to include this discussion in the paper.

Author Response: Thank you for this comment. We had already stated the following statements in our manuscript.

We did not cross-verify the dates with IMD onset dates. Nonetheless, Li et al. (2024) provide a detailed overview of how strongly different onset indices correlate with IMD onset dates. The TT index exhibits a significant correlation with IMD onset dates, which is typically true for most monsoon onset indices (Bombardi et al. 2020).

Nonetheless, following the reviewer's comment we contrasted SST 10-15 days before early and late monsoon onset cases, considering the IMD declared onset dates. The SST warm anomalies for early onset cases over BoB are still noticeable although the distribution of the warm anomalies is different (more widespread) from Figure 3a of the main manuscript. In our latest revision, following the reviewer's suggestion, we have updated Supplementary Figure S2 including a plot showing SST difference computed using IMD-declared monsoon onset dates (obtained from Table 1 of Satish and Suneetha, 2022) for the period 1985–2019, and included the following statement in the revised manuscript. Lines 156-159 of the revised manuscript in track-changes format:

> A preliminary analysis reveals that these warm anomalies are largely insensitive to the definition of monsoon onset. When IMD-declared monsoon onset dates are considered, SST warm anomalies over the BoB associated with early-onset cases remain evident (Supplementary Figure S2), although the anomaly distributions differ (more widespread) from those shown in Figure 3a.

Thank you.

Reviewer comment #3. How does inter annual forcing such as El Nino affect the onset dates and the SST anomalies over BoB? Please include a discussion on the same.

Author Response: Thank you for this insightful comment. Following reviewer's suggestion, we have included the following statements in our revised manuscript. Lines 347-357 of the revised manuscript in track-changes format:

> It is noteworthy that, analyzing IMD-declared monsoon onset dates, Preenu et al. (2017) found that El Niño (La Niña)-type SST anomalies are associated with delayed (early)

monsoon onset. A case study of the 2019 monsoon by Sankar et al. (2021) corroborates this. They argue that the 2019 delayed monsoon onset was partly caused by the presence of an El Niño Modoki. On the other hand, analyzing monsoon onset defined by the rainfall accumulation-based criteria of Liebmann and Marengo (2001), a recent study by Jayasankar and Misra (2025) did not find any robust teleconnection between monsoon onset and interannual forcing such as ENSO or IOD. The discrepancy in findings on the co-variability of monsoon onset timing with interannual forcing like ENSO partly stems from differences in definitions of monsoon onset. In this regard, it is noteworthy that we found robust warm anomalies over the Bay of Bengal favoring early onset for two different definitions of monsoon onset (tropospheric temperature-based onset dates: the dates indicated in Figure 2 and SST anomalies in Figure 3a; and IMD-declared onset dates: the dates indicated in Table 1 of Satish and Sunnetha (2022) and SST anomalies in Supplementary Figure S2). Hence, investigating the source of these warm anomalies remains our top future research priority.

Thank you.

We thank the Reviewer again for their valuable time.