Response to Community Comments by Prof. Peng Hu and Reviewer #2

General comment

The manuscript presents a synoptic circulation–based clustering approach (NL26) for defining the South China Sea summer monsoon onset. Overall, the study is well-conceived and methodologically sound. The proposed approach demonstrates substantial improvements in deterministic, categorical, and probabilistic prediction skill relative to the conventional U850-based onset definition (Wang et al., 2004; W04). The analysis is comprehensive, and the findings are potentially valuable for improving seasonal forecasts. However, several aspects of the manuscript require further clarification and elaboration before the work can be considered for publication.

Response

The community comments submitted by Prof. Peng Hu and the comments submitted by Reviewer #2 raise largely overlapping points. To avoid duplicating the same responses, we provide a combined response to these comments below, while keeping the anonymous reviewer identity separate from the named community comment. We sincerely thank Prof. Peng Hu and Reviewer #2 for the careful reading of the manuscript and for their constructive comments and helpful suggestions. We appreciate their positive assessment that the study is well conceived, methodologically sound, and potentially valuable for improving seasonal forecasts of SCSSM onset. We also appreciate their suggestions for improving the clarity, balance, and presentation of the manuscript. In response, we have revised the manuscript substantially by adding a table of abbreviations and key forecast verification metrics, expanding the explanation of the differences between NL26 and W04, adding a more balanced discussion of methodological limitations, discussing the implications of the recently weakened ENSO–SCSSM onset relationship for forecast skill during the independent period (2017–2025), and removing the phrase “also known as the East Sea in Vietnam”.

Major comments

Comment 1: Abbreviations and notation

This manuscript employs numerous abbreviations (e.g., OD, NL26, W04, RPC, ACC, HSS, RPSS, BSS), which may impede readability. It is strongly recommended that the authors provide a dedicated table summarizing all abbreviations and their definitions for clarity.

Response

We agree and have added Table 1, which summarizes the main abbreviations and key forecast verification metrics used in the manuscript, including NL26, W04, RPC, ACC, HSS, BSS, RPSS, U_{SCS}, and OLR_{SCS}. This table was placed near the beginning of the manuscript to improve readability.

Changes in manuscript

Added Table 1, “Main abbreviations and key forecast verification metrics used in this study.”.

Comment 2: Differences between NL26 and W04 onset dates

Figure 2 indicates that the NL26 onset dates differ from W04 in certain years, but the current explanation is rather generic (e.g., “reflecting the persistence and maturity criteria”). The authors should provide a more detailed, year-specific analysis of these discrepancies. For example, are delayed onsets due to brief westerly intrusions being excluded by the persistence criterion? Are earlier onsets associated with an early and coherent transition to monsoon-type circulation? A more mechanistic discussion would enhance the reader’s understanding of the advantages and physical basis of the NL26 definition.

Response

We agree with this comment and have substantially revised the discussion following Figure 2. The revised text now explains more explicitly that the W04 definition is sensitive to threshold crossing in area-averaged low-level zonal wind, whereas NL26 emphasizes coherent regime transition and monsoon maturity. We also added representative year-specific examples in Figs. S4 and S5 to illustrate two contrasting situations: a case in which NL26 identifies onset earlier than W04 because a coherent monsoon-type circulation is already established, and a case in which W04 identifies onset earlier because the zonal-wind threshold is crossed during a brief westerly surge before a mature monsoon regime is established. These additions provide a more mechanistic explanation of the physical basis and advantages of NL26.

We also note that the revised skill values differ from those in the original submission because both the NL26 definition and the category definition were updated, and all prediction metrics were recalculated accordingly.

Changes in manuscript

Final NL26 onset definition has been revised.

Rewrote the Figure 2 discussion and added a more mechanistic explanation with representative cases.

Added Supplementary Figs. S4 and S5.

Comment 3: Limitations of the proposed method

The manuscript primarily emphasizes the benefits of the NL26 approach but does not adequately discuss its potential limitations, which may include: (a) applicability in real-time operational forecasting contexts, (b) complexity of implementing the SOM plus K-means workflow, which could pose challenges for replication, (c) sensitivity to extreme events or limited sample years. A discussion of these limitations would provide a more balanced and rigorous assessment of the method.

Response

We agree and have added a new limitations paragraph in Section 5.1. This paragraph now discusses: (a) the challenge of applying the clustering-based framework in real-time operational prediction; (b) the greater methodological complexity of the SOM plus K-means approach relative to conventional threshold-based definitions; (c) the sensitivity of skill estimates to a short independent verification period and to a few unusual years; and (d) the need for additional diagnostics and testing in other monsoon systems and forecast models. We believe this addition provides a more balanced assessment of the strengths and limitations of the proposed method.

Changes in manuscript

Added a paragraph of limitations in the Discussions.

Comment 4: Weakening relationship between SCSSM onset and ENSO

The manuscript discusses the modulation of SCSSM onset by ENSO. However, recent studies suggest a interdecadal weakening of the ENSO–SCSSM onset relationship (Hu et al. 2022; Hu et al. 2026). The authors should acknowledge this weakening relationship and discuss its potential implications for forecast skill in the independent verification period (2017–2024).

Hu P, Chen W, Chen S, et al. The weakening relationship between ENSO and the South China Sea summer monsoon onset in recent decades. Advances in Atmospheric Sciences, 2022, 39(3): 443-455.

Hu P, Chen W, Cai Q, et al. Delayed tropical Asian summer monsoon onset in recent decades. Geophysical Research Letters, 2026, 53(1): e2025GL120825.

Response

We thank the reviewer for this important suggestion. In the revised manuscript, we now explicitly acknowledge the recently weakened ENSO–SCSSM onset relationship and discuss its implications for forecast skill during the independent period. Specifically, we added text in Section 4.2.1 noting that although ENSO-related SST anomalies remain an important source of background modulation, the weakened ENSO–SCSSM onset relationship in recent decades may reduce the strength and stability of seasonal predictability, especially during 2017–2025. We also note that this weakening may partly explain why forecast skill in the independent period is lower and less statistically robust than during the dependent period, particularly for the conventional W04 definition.

Changes in manuscript

Added discussion of the weakened ENSO–SCSSM onset relationship and its implications for independent-period skill.

Added Hu et al. (2022c) and Hu et al. (2026) to the references.

Comment 5

Please delete the phrase “also known as the East Sea in Vietnam”, as this name is not widely recognized or accurate for the international audience.

Response

We agree and have removed this phrase from the Introduction.

Changes in manuscript

Phrase removed from the Introduction.

References

Chevuturi, A., Turner, A. G., Woolnough, S. J., Martin, G. M., and MacLachlan, C.: Indian summer monsoon onset forecast skill in the UK Met Office initialized coupled seasonal forecasting system (GloSea5-GC2), Clim Dyn, 52, 6599–6617, https://doi.org/10.1007/s00382-018-4536-1, 2019.

Chevuturi, A., Turner, A. G., Johnson, S., Weisheimer, A., Shonk, J. K. P., Stockdale, T. N., and Senan, R.: Forecast skill of the Indian monsoon and its onset in the ECMWF seasonal forecasting system 5 (SEAS5), Clim Dyn, 56, 2941–2957, https://doi.org/10.1007/s00382-020-05624-5, 2021

Mao, J. and Wu, G.: Influences of Typhoon Chanchu on the 2006 South China Sea summer monsoon onset, Geophysical Research Letters, 35, 2008GL033810, https://doi.org/10.1029/2008GL033810, 2008.

Wang, B., LinHo, Zhang, Y., and Lu, M.-M.: Definition of South China Sea Monsoon Onset and Commencement of the East Asia Summer Monsoon*, Journal of Climate, 17, 699–710, https://doi.org/10.1175/2932.1, 2004.