Response to Reviewer 2's Comments:

This paper investigates the dynamics of the Asian Summer Monsoon Anticyclone (ASMA) using three modern reanalysis datasets (ERA5, MERRA-2, and JRA-3Q) and introduces a potential vorticity (PV) tendency diagnostic to disentangle dynamical and thermodynamical contributions to ASMA evolution. The study identifies a trimodal structure of the ASMA (Iranian Plateau, Tibetan Plateau, and Western Pacific/Bonin High) and examines the roles of horizontal advection and diabatic heating in modulating its propagation, intensification, and eddy-shedding behavior. The topic is relevant and within the scope of the journal, and the use of multiple reanalyses combined with PV diagnostics is potentially valuable. While the topic is relevant and the use of multiple reanalyses is commendable, the manuscript in its current form has several critical issues that must be addressed before publication.

Major Comments:

1. The estimation of latent heating in ERA5 using radiation fluxes and "precipitation-related top latent heat flux (mttpm)" raises concerns. These variables do not directly represent the vertical structure of latent heating, which is crucial for PV generation. This approximation may introduce uncertainty into the diabatic contribution to PV tendency. The assumptive latent heating in ERA5 shows large difference from that in Merra2 and JRA-3Q in Fig.8. The authors should provide justification and supporting references for this approach, perhaps by showing the comparison with datasets that include explicit latent heating or the spatial patterns of "mttpm" correlate well with upper-tropospheric diabatic heating from other reanalyses. Limitations in both the methodology and conclusions should be discussed to justify its use.

   Response: We sincerely appreciate the reviewer's comments on the estimation of latent heating in ERA5 and its uncertainty in the diabatic contribution to PV tendency. We fully agree that the vertical structure of latent heating is critical for PV generation, and the approximation in ERA5 requires justification, comparison, and a discussion of the limitations.

   ERA5 does not provide a direct diagnostic of latent heating rate on isentropic or pressure levels required for PV tendency calculation. To resolve this, we use net non-radiative heating as a proxy for latent heating,

   1) Net shortwave radiative heating (mttswr) + net longwave radiative heating (mttlwr) together represent the radiative heating component.
   2) Subtracting the radiative heating component from the total heating as mttpm – (mttswr+mttlwr) indirectly quantifies the heating due to convection, clouds, and

related processes.

Our previous work (see Figs. R1-R3 below) indicates that the non-radiative heating (Fig. R2) is dominated by convective and latent heating, as the other main component of non-radiative heating, that due to shear-flow turbulent mixing (Fig. R3), is more than an order of magnitude smaller than the total non-radiative component. Differences in non-radiative heating among different reanalyses are significant near the tops of convective clouds, which also impose differences in the vertical structure of radiative heating at these altitudes (see Wright et al. 2020).

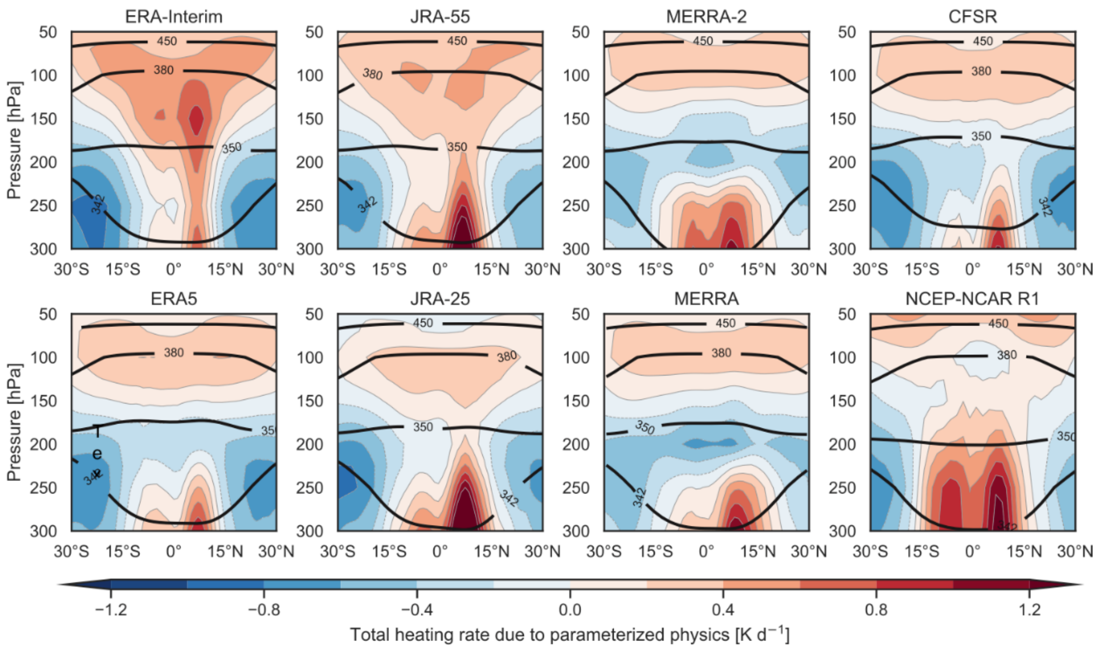

Fig. R1. Zonal mean total diabatic temperature tendencies (Q/cp in K day^{-1}; shading and gray contours) and potential temperature (θ in K; black contours) averaged over 1980-2010 for two generations of reanalyses from ECMWF (far left), JMA (center left), NASA GMAO (center right), and NOAA NCEP (far right). From Tegtmeier et al. (2022), updated from Wright and Fueglistaler (2013).

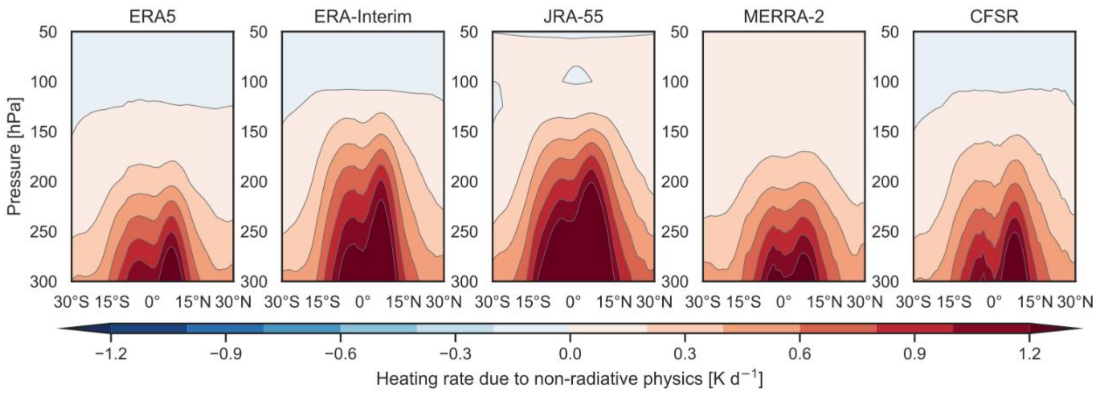

Fig. R2. As in Fig. R1 but for the "non-radiative component" from ERA5, ERA-Interim, JRA-55, MERRA-2, and CFSR. From Tegtmeier et al. (2022), updated from Wright and Fueglistaler (2013).

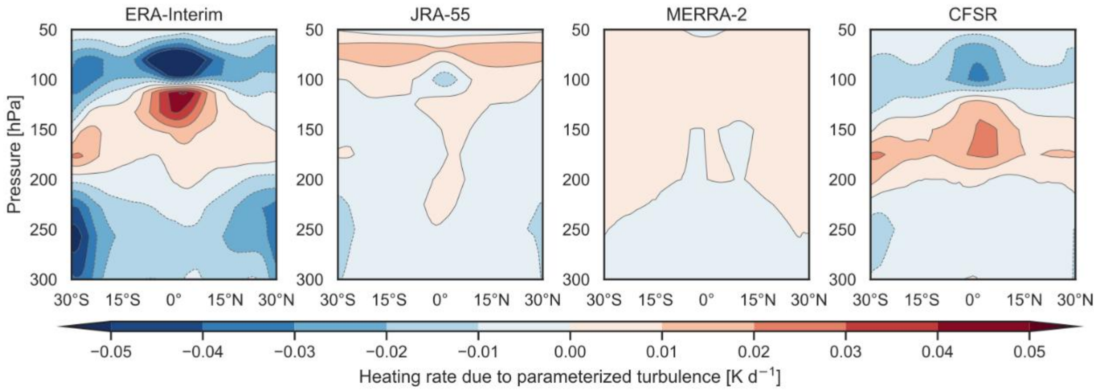

Fig. R3. As in Fig. R1 but for the "vertical diffusion" component from ERA-Interim, JRA-55, MERRA-2, and CFSR. Note the difference in color scale. From Tegtmeier et al. (2022), updated from Wright and Fueglistaler (2013).

2. The vortex tracking method has already been well-documented in prior work (Siu and Bowman, 2020) and could be significantly condensed. The core novelty—the PV tendency diagnostic and its application to understanding the three modes—should be the central focus. The derivation and presentation of the PV tendency equations (Eq. 7-10) are difficult to follow. Please provide a clear and consistent derivation. Some terms are introduced without sufficient explanation.
Response: Thank you. We agree, and have substantially shortened Section 3.1 on vortex tracking, focusing on the key steps relevant to this study (370 K isentropic surface, zero-zonal wind, MSF maximum, relative vorticity filtering, persistent/transient definition). This change helps to make the manuscript more concise and compact.
We have also revised Section 3.2 considerably, eliminating the PV tendency equation in pressure coordinates in favor of using exclusively isentropic coordinates in the revised manuscript.

Minor comments:

L100: "including zonal wind, u, MSF, ψ , and relative vorticity, ζ ." --Consider changing to "including zonal wind (u), MSF (ψ), and relative vorticity (ζ)."
Response: Changed as suggested. (L109-110)

L142: Please move Eq.2 ahead to Sec 3.1, as MSF is already mentioned there.
Response: Thank you, we have done this (L109).

L161: The second term on the right-hand side of Eq.6 appears unnecessary based on Eq.3 and Eq.5.

Response: Thank you for your comment. This paragraph has been removed from the revised text.

L179: Eq.8 is difficult to follow

Response: Thank you; we have rewritten this entire section to make it more understandable for readers. (Section 3.2)

L199-201 and caption of Fig.2: Please specify which reanalysis was used for the results.

Response: Thank you for noticing this omission. The plotted data are from JRA-3Q, as is now indicated in the caption of Fig.2.

L226: “eddy shedding events” -- Are all eddy shedding events marked by the gray and dashed circles in Fig. 4, or only some examples? Is there a clear definition of an eddy shedding event?

Response: In Fig. 5 (previously Fig. 4), we mark only typical, visually clear cases to illustrate the eddy shedding behavior, rather than attempting to label every event. This approach is consistent with standard visualization practice in ASMA variability studies.

There is no universally accepted quantitative threshold for defining eddy shedding in the ASMA, as it involves gradual vortex splitting, detachment, and westward/eastward propagation that is inherently continuous and difficult to discretize objectively. For consistency with previous literature, we adopt the qualitative approach widely used in related studies (e.g., Popovic and Plumb, 2001; Siu and Bowman, 2020; Wang et al., 2022).

L233-234: The zonal advection and vertical advection of PV are positive (negative) in the west (east) of anticyclone in Fig.5. They are not always positive or negative above 300hPa. Please rephrase this sentence for clarity.

Response: Thank you. We agree that the original statement was not sufficiently precise. The pattern described at L233–234 represents the composite/statistical mean behavior derived from all analyzed cases, rather than a feature that holds in every individual event. Above ~300 hPa, in the composite mean, zonal advection tends to produce positive PV tendency to the west of the anticyclone core and negative PV tendency to the east, while vertical advection is dominated by positive values near the center and negative values farther eastward. We have revised the text to clearly indicate that this is a statistical composite result, not a universal feature of every case.

P15: Please include the values of PV anomaly in the black dashed contours in Fig. 5, as is done in other figures.
Response: Thank you for this suggestion. We have updated Fig. 6 (previous Fig. 5) to include these, along with labels for dashed contours.

P16, Caption of table 3: “while the northward direction is taken as negative in the tripole patterns ...” -- Please confirm whether the northward direction is taken as negative or positive.
Response: Thank you. It is a typo; the northward direction should be positive, and the caption of table 3 has now been corrected.

L308-310: The description of the results in Fig.8 is unclear. Consider revising to: In contrast, the effect of mean meridional advection opposes that of mean zonal advection; specifically, mean meridional advection intensifies anticyclones for all three modes in the west, and also intensifies the TP and BH anticyclone in the east, while diminishing IP anticyclone in the east.
Response: Thank you for your suggestions; we have modified the sentence in L308-310 with reference to your suggestion.

L314: The latent heating for ERA5 looks quite different from that in Merra2 and JRA-3Q in Fig.8. Is the assumptation for ERA5 latent heating reasonable? Please carefully revise this whole paragraph discussing Fig.8.
Response: Thank you for pointing out this critical issue. We have carefully checked Figure 8 and found that the discrepancy of non-radiative heating in ERA5 relative to MERRA-2 and JRA-3Q was caused by a plotting error in the original figure. We have now completely revised and replotted Figure 8, and the inconsistency of ERA5 latent heating has been reduced.

As mentioned above, ERA5 does not provide a direct latent heating term, so we have used non-radiative heating as a proxy. This indirect scheme has been used successfully in previous UTLS and ASMA-related studies and aligns well with the typical dominance of latent heating relative to other non-radiative components at these altitudes. Comparison with moist physics terms from MERRA-2 and JRA-3Q in the revised Figure 7 and 8 indicates that our estimation of ERA5 latent heating is physically reasonable.

L317: “ASMA is stronger than in eastward in TP and BH modes...” -- change to “ASMA is stronger than in westward...”. Also note that “both the intensification and propagation are negative PV tendency”, but the intensification appears as positive in Fig.9. Please clarify.

Response: We improved this phrasing to made it easier to understand.

P18: The caption about Fig.8 is unclear. I had to read it several times to understand the different terms in the plot. Please revise. The "meridional mean advection" in Fig.8(a-f) -- consider change to "mean meridional advection".
Response: Thank you. We changed the caption (now Fig. 13) to "Contributions of dynamical and thermodynamic processes in Eq. (5) to mean PV tendencies to the (a–c) west of the vortex center and (d–f) east of the vortex center on the 370 K isentropic surface. From left to right, each group of three bars corresponds to JRA-3Q, ERA5, and MERRA-2. Numbers on bars denote the percentage contribution of each term. Terms include mean zonal advection, meridional mean advection, nonlinear horizontal advection, vertical advection, and the vertical divergence of latent, radiative, and diabatic heating. See section 3.2 for definitions."

P19: Check the caption of Fig.9. Please confirm whether the value next to each bar shows the relative contribution to PV tendency.
Response: We have checked and modified the caption. The vertical bars show q_{dev}, q_{int}, and q_{prop} derived from the three reanalysis datasets. For q_{dev} (first bar), values indicate the absolute PV tendency (PVU day^{-1}). For q_{int} and q_{prop} (second and third bars), values denote the relative contribution (%) to the total PV tendency. Westward and eastward propagation are indicated by diagonal and dot textures, respectively (now Fig. 14).

P21: Please clarify what the "PV tendency anomalies" refer to in Fig.10 and Fig.11?
Response: As the revised manuscript exclusively examines the analysis in potential temperature coordinates, we have removed these figures.

General: Improve figure captions to clearly state main findings.
Response: The figure captions have been updated. We hope that the revised captions will be clearer and easier to understand.

References

All references cited in this reply are included in the reference list of the revised manuscript.