Responses to comments of " Contrasting Impacts and Mechanisms of Clustered versus Isolated Summer Atmospheric Rivers on Arctic Sea Ice Melt " egusphere-2026-1025 to TC

We thank Referee #2 for the detailed review and for identifying several scientific and presentation issues in the original manuscript. We agree that the original version relied too heavily on two illustrative cases, contained figure-text inconsistencies, and did not provide enough methodological detail to support the breadth of its conclusions. Below we provide a point-by-point preliminary response describing how we plan to address each concern in a revised manuscript. A full marked-up manuscript will be provided if a formal revision is requested.

General comments

Comment 1. The manuscript relies on two AR cases that have already been documented by Li et al. (2024), and the additional contribution is not sufficiently supported.

Response: We will revise the manuscript so that the main contribution is no longer a reanalysis of only the 2012 and 2020 cases. The revised study will use a multi-year, multi-region event framework to test whether the temporal organization of regional AR pulses modifies sea-ice melt-equivalent potential. Li et al. (2024) will be cited clearly as prior work documenting AR impacts on Arctic sea ice, and the novelty of the revised manuscript will be framed as an event-based comparison of clustered, isolated, and transitional regional AR-pulse timing, including matched controls and mechanism-budget diagnostics. The 2012 and 2020 cases will be retained only as illustrative supplementary examples.

Comment 2. Several figures, especially those supporting Sections 3.2 and 3.3, are inconsistent with the text and do not clearly support the conclusions.

Response: We will rebuild the figure set and ensure that every figure, caption, and text reference describes the same variables, periods, and samples. Figures that were inconsistent in the original manuscript will be replaced or moved to the Supplement as illustrative case figures. The revised main figures will include a study-framework and sector map, matched-pair contrasts, multi-region contrasts, spatial composites and shortwave-attribution diagnostics.

Comment 3. Many statements extend beyond the evidence shown in the figures and are not supported by references or additional analyses.

Response: We will conduct a full claim audit. Broad or speculative statements will be removed or supported by explicit analyses or citations. The revised manuscript will distinguish clearly between evidence presented in the study and limitations or hypotheses for future work.

Comment 4. The organization is confusing because ARs are discussed before the events are clearly identified and introduced.

Response: We will reorganize the manuscript. A figure showing the analysis sectors and conceptual event framework will appear early in the manuscript. The revised Results will begin with the multi-region AR-pulse sample and classification before presenting energy-budget and melt-response diagnostics.

Comment 5. A figure should clearly show the timing, location, evolution, and classification of detected AR events.

Response: We will add a figure and supporting tables that make the regional AR-pulse framework explicit. The revised figure set will show the four analysis sectors, the clustered/isolated/transitional classification logic. Event counts and classes will be summarized in a table and supplementary climatology figure. For the 2020 and 2012 illustrative cases, supplementary figures will show the timing and spatial evolution with consistent variables and captions.

Comment 6. Gemini language editing is acknowledged, yet many broad interpretations lack support.

Response: We will revise the manuscript into standard scientific prose. All scientific statements will be supported by either analyses shown in the manuscript or by citations. Broad interpretive language, unsupported terminology and speculative claims will be removed.

Major comment 1: Abstract and Introduction

Comment 7. The Abstract and Introduction imply a systematic analysis, while the original manuscript is based on two cases.

Response: We will revise the scope of the study. The revised manuscript will no longer present the main analysis as a two-case comparison. Instead, it will use a 1990-2024 JJA multi-region event framework with clustered, isolated, and transitional regional AR pulses. The claims will be limited to the evidence supported by the event-based analysis, and the 2012/2020 cases will be described as supplementary examples.

Comment 8. The statement about a "systematic comparison" is misleading in a two-case study.

Response: We will remove the original wording and replace it with a description of the revised event-based design. The revised wording will state that the study tests how temporal clustering of regional AR pulses modifies melt-equivalent potential using multi-year event classification.

Comment 9. The Introduction needs substantially more citations.

Response: We will add citations for Arctic amplification, ice-albedo feedback, atmospheric moisture intrusions, AR impacts on sea ice, dynamic and thermodynamic pathways, Arctic surface-energy budgets, and sea-ice preconditioning.

Major comment 2: Data and Method

Comment 10. SIC data are not described in Section 2.

Response: We will add a full description of the sea-ice data. ERA5 SIC will be described as the event-state variable used in matching and response diagnostics. OISST ice fraction will be added as an independent daily sea-ice consistency and event-response check. OSI SAF sea-ice drift will be added as a dynamic-redistribution constraint. The revised Methods will explain the role and limitations of each product.

Comment 11. IVT calculated by integrating pressure-level data from 1000 to 300 hPa may omit part of the atmospheric column in regions where surface pressure is below 1000 hPa.

Response: We will avoid this ambiguity in the revised analysis by using ERA5 vertically integrated eastward and northward water-vapour flux fields directly to calculate IVT. These single-level ERA5 diagnostics are vertically integrated by the reanalysis system and do not require manual pressure-level integration from 1000 to 300 hPa. The Methods will explicitly define IVT as the magnitude of the ERA5 vertically integrated horizontal water-vapour flux components.

Comment 12. The AR identification and tracking algorithm is not described clearly.

Response: We will rewrite the AR-pulse identification method in detail. The revised manuscript will define the analysis sectors, specify whether thresholds are regional or grid-point based, define the JJA regional IVT climatology, state the minimum duration criterion, and describe the clustered, isolated, and transitional classification rules.

Comment 13. The target sector domain should be defined.

Response: We will provide exact latitude-longitude bounds for all four sectors and show them in an early figure. Sector means will be area-weighted and all event classifications will be computed separately within each sector.

Comment 14. "Local summer climatology" and threshold application need clarification.

Response: We will replace ambiguous "local summer climatology" language with explicit definitions. The revised manuscript will state that thresholds are calculated from JJA regional IVT distributions within each sector. If grid-point diagnostics are used in spatial composites, they will be described separately from the regional event classification.

Comment 15. The threshold value of 200 kg m^-1 s^-1 should be verified.

Response: We will remove reliance on an ambiguous fixed-threshold statement and define the primary AR-pulse criterion using a regional percentile threshold with a minimum-duration requirement. We will include sensitivity tests using alternative IVT percentile thresholds.

Comment 16. Section 2.3.2 does not explain whether spatial overlap is used to connect AR features between time steps.

Response: We will clarify that the primary regional AR-pulse framework is based on continuous threshold exceedance within a defined sector. To address this limitation, we will include an external PIKART object-catalogue check.

Comment 17. A figure showing the analysis domain would improve clarity.

Response: We will add a study-domain and sector map as a main figure. This figure will show the cross-dateline, East Siberian-Laptev, Chukchi-Beaufort, and central Arctic sectors and will be referenced before the event and mechanism analyses.

Major comment 3: Figures

Comment 18. Figure 1 domain and averaging period are unclear.

Response: We will remove or replace the original Figure 1. The revised main figure will show the study framework and analysis sectors. Any time series or climatological context included in the revised manuscript will define the averaging domain and period directly in the caption and Methods.

Comment 19. Many statements in Section 3.1 are not supported by Figure 1 alone.

Response: We will remove broad claims about basin-wide retreat, synoptic pulses dictating the summer minimum, and future regime shifts. The revised Results will focus on diagnosed event-scale metrics. Broader implications will be moved to the Discussion and written with clear limitations.

Comment 20. Figure 2 needs a clear definition of whether it is monthly mean, composite, daily average, or event period.

Response: All revised figures will state whether they show event-period values, matched contrasts, daily diagnostics, or spatial composites. Figure captions will identify the time window and sample used.

Comment 21. Figure 3 needs a clear averaging period.

Response: The revised captions will define the averaging or accumulation period for every map or composite. If the figure shows a specific event, the exact dates will be stated. If the figure shows a composite, the event sample and relative time window will be stated.

Comment 22. Figures 4-8 contain caption-content inconsistencies.

Response: We will rebuild the figure set to remove these inconsistencies. The revised figures will use a consistent variable order and will be checked against the text before submission. The 2020 and 2012 case figures will be placed in the Supplement with captions stating that they are illustrative.

Specific comments

Comment 23. The manuscript repeatedly refers to "code"; code is a tool and should not be treated as a scientific result.

Response: We will minimize references to code in the scientific narrative. Code will be discussed only in the Methods where it clarifies reproducibility, and in the Code and Data Availability section.

Comment 24. There is an extra question mark and several acronym/definition issues.

Response: We will proofread the manuscript for punctuation. LHF, SHF, IVT, SIC, DLR, SKT, and other abbreviations will be defined at first use.

Comment 25. Phrases such as "canary in the coal mine", "dynamic pump", and "dynamic corridor" need citation or replacement.

Response: We will remove these informal or ambiguous phrases. Where a physical process is intended, it will be described using standard terminology.

Comment 26. The 2012 case needs corresponding figures and clearer integration with the analysis.

Response: The 2012 case will be moved to the Supplement and treated as a dynamically influenced illustrative case. It will not be used as the sole isolated-event control. Its supplementary figures will use the same variable order and sign conventions as the 2020 illustrative case.

Comment 27. Evidence for clustered AR identification is not clearly shown.

Response: The revised manuscript will include a clear event classification framework and event counts. The clustered/isolated/transitional classification will be defined in the Methods and summarized in tables and figures.

Comment 28. Claims about radiative-dynamic coupling, warm-air advection, emissivity, IWV, inversions, and other mechanisms need evidence or citations.

Response: We will remove unsupported mechanism statements or support them with specific diagnostics and citations. The revised mechanism will focus on variables directly analysed: IVT, Qnet, SWnet, LWnet, DLR, SHF, LHF, SKT, SIC, OISST ice fraction, CERES radiation, PIKART AR masks, and OSI SAF drift.

Comment 29. Section 3.2.1 refers to "three distinct, high-intensity pulses" without a figure clearly demonstrating them.

Response: The main manuscript will no longer rely on this case-specific statement to support the general conclusion. The 2020 case will be retained in the Supplement with time series showing the pulse sequence. The main Results will use the multi-year event classification and matched comparison.

Comment 30. Several figure references do not show the variables discussed.

Response: We will audit every figure reference and ensure that the referenced figure contains the variable discussed in the text.

Comment 31. The statement about projected increases in stagnant blocking patterns needs references.

Response: We will remove broad future-projection claims. The revised manuscript will focus on observed 1990-2024 event behaviour and will avoid unsupported claims about future blocking-frequency trends.

Comment 32. Data and Code Availability need a more complete description.

Response: We will expand the Code and Data Availability section to list ERA5, OISST, CERES, PIKART, and OSI SAF, making the event detection and analysis workflow reproducible.