Response to Reviewer 2 Comments

1. Summary

Thank you very much for taking the time to review our manuscript and for providing detailed and constructive comments. We sincerely appreciate your critical assessment of the manuscript. Your comments helped us recognize that the previous version relied too heavily on qualitative descriptions and map-based interpretation, while the quantitative support, methodological clarity, and technical presentation were insufficient.

In response to your comments, we substantially revised the manuscript by weakening overgeneralized conclusions based on the limited event sample, removing the unsupported 12–6 h "key prediction window" statement, adding quantitative ERA5-based dynamic and thermal anomaly diagnostics, clarifying the anomaly baseline, lead-time definition, spatial averaging domains, and HYSPLIT settings, presenting the HYSPLIT pathway interpretation more cautiously, replacing the previous flux-centered analysis with tower-observed wind and temperature anomaly profiles, revising the Discussion to include limitations and outlook, and correcting technical issues related to Table 1, station names, HYSPLIT spelling, Table 3, figure captions, terminology, and references. The revised manuscript is provided with tracked changes, and the major textual changes are specified below by location, original wording, and revised wording.

2. Point-by-point response to Comments and Suggestions for Authors

Major issues

Comments 1

Reviewer comment: Too small sample size: The study is effectively based on only eight dust-storm cases from a single season in 2024, after one event was excluded because of missing data at one station. This is too limited a sample to robustly establish generalized trajectory classes, seasonal controls, or forecasting windows. The manuscript often phrases its findings in broad terms, but the evidence is based on a very small number of cases, making it difficult to separate systematic behavior from event-specific variability.

Response: *Thank you very much for this important and helpful comment. We fully agree with the reviewer that eight dust-storm events from one field season are not sufficient to establish generalized trajectory classes, universal seasonal controls, or validated forecasting windows. We also appreciate this comment because it helped us reconsider and clarify the actual scope of the present study.*

In the revised manuscript, we have made it clearer that the purpose of this study is not to propose a new universal classification of dust-storm pathways over the Taklimakan Desert, since dust-storm transport pathways in this region and its surroundings have already been investigated by many previous studies. Instead, our intention is to examine several relatively recent dust-storm processes observed in 2024 with comparatively complete tower observations. Based on these cases, we aim to analyze how the pre-storm airflow pathways corresponded to changes in the meteorological background before dust-storm onset, and how the associated wind-speed, wind-shear, and temperature responses were reflected at one desert-interior station and one desert-margin station.

Following the reviewer's suggestion, we have revised the manuscript to avoid broad or generalized statements that are not supported by the limited event sample. The pathway interpretation is now restricted to the analyzed cases, the seasonal dynamic–thermal contrast is described as event-based observational evidence, and the previous 12–6 h "key prediction window" conclusion has been removed. We have also added a limitation statement in the Discussion, noting that longer-term event samples are needed to further test the pathway-related and seasonal characteristics identified in this study.

Detailed changes made in the manuscript:

***Location in revised manuscript:** Abstract*

***Original text:** Based on dual-gradient observational experiments in the central and peripheral regions of the TD, combined with ERA5 data and HYSPLIT analysis, eight dust storms from April to June 2024 were studied. The findings include that dust-storm trajectories in the TD fall into three types and that significant pressure and temperature changes 12–6 hours before a storm provide a critical prediction window.*

***Revised text:** This study combined dual-gradient tower observations from Tazhong (TZ) and Xiaotang (XT), ERA5 reanalysis, and HYSPLIT backward trajectories to examine eight dust-storm events in spring and summer 2024. The Abstract now describes "pre-storm airflow pathways" and concludes that the findings provide observational evidence for seasonal differences in TD dust-storm processes.*

***Reason for this revision:** The Abstract was revised to state the limited event sample clearly, avoid broad pathway generalization, and remove the unsupported forecasting-window claim.*

***Location in revised manuscript:** Sect. 3.1 "Dust Storm Trajectory Analysis"*

Original text: *The original text stated that "the conclusion can be drawn that the dust storm trajectories in the TD are complex" and described pathway categories as general dust-storm trajectory types for the TD.*

Revised text: *The revised text states that "the analyzed dust-storm events were associated with three main types of pre-storm airflow transport pathways" and that east-inflow transport was the most frequent "in the analyzed cases".*

Reason for this revision: *The wording now limits the pathway interpretation to the eight analyzed events instead of implying a general TD pathway classification.*

Location in revised manuscript: *Sect. 3.3 "Analysis of Dynamic and Thermodynamic Factors"*

Original text: *The original text inferred broad seasonal dominance from pressure and temperature maps, including that pressure changes play a more direct role in spring and that temperature changes have a more significant impact on summer dust storms.*

Revised text: *The revised text states that spring events were "more closely linked to persistent dynamic forcing", whereas summer cases showed "stronger early thermal preconditioning", and it adds that the seasonal difference is not a complete separation between dynamic and thermal mechanisms.*

Reason for this revision: *The revised wording separates event-based evidence from broad mechanistic generalization and avoids treating the limited sample as a climatological proof.*

Location in revised manuscript: *Sect. 4 "Discussion"*

Original text: *The previous Discussion repeated results and stated that the combined analysis "further proves" the seasonal differences in dust-storm formation.*

Revised text: *A limitations paragraph was added: "The analysis is based on eight events from one field season, and the identified pathway and seasonal characteristics need to be tested using longer-term samples."*

Reason for this revision: *This revision explicitly acknowledges the sample-size limitation and frames the findings as requiring longer-term verification.*

Location in revised manuscript: *Sect. 5 "Conclusion"*

Original text: *The original Conclusion stated that dust-storm trajectories in the TD can be classified into three types and that the 12–6 h period can be used as a key prediction window.*

Revised text: *The revised Conclusion states: "The analyzed events exhibited three main types of pre-storm airflow transport pathways ..." and removes the 12–6 h key-prediction-window conclusion.*

Reason for this revision: *The conclusions now match the limited evidential scope of the study and no longer overstate pathway classification or forecasting applicability.*

Comments 2

Reviewer comment: The central claim that spring storms are dynamically dominated while summer storms are thermally dominated is reasonable, but the manuscript does not provide sufficiently strong quantitative evidence to support this as a robust mechanistic conclusion. Much of the argument relies on visual comparison of maps, narrative interpretation of pressure and temperature changes, and descriptive contrasts between a few cases. Similarly, the proposed 12–6 hour "key prediction window" is inferred from variance behavior rather than validated with any formal predictive framework or skill assessment. These conclusions therefore appear suggestive rather than firmly demonstrated.

Response: *Thank you for this valuable and critical comment. We agree that the previous version relied too much on qualitative map interpretation and variance-table descriptions. We added ERA5-based quantitative anomaly diagnostics and revised the language from a strict "spring dynamic dominance versus summer thermal dominance" framework to a more cautious interpretation. We also removed the previous 12–6 h key prediction-window conclusion because no formal predictive framework or skill assessment was conducted.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Sect. 2.3 "ERA5 Reanalysis Data"*

Original text: *The original manuscript described ERA5 mainly as a source of meteorological fields and did not define quantitative diagnostic indicators or anomaly baselines.*

Revised text: *The revised manuscript defines dynamic indicators as mean sea-level pressure-gradient magnitude, 850 hPa geopotential-height-gradient magnitude, and 10 m wind speed. It defines thermal indicators as 2 m air temperature, skin temperature, surface–air temperature difference, surface net shortwave radiation, and boundary-layer height.*

Reason for this revision: *These additions provide a quantitative basis for comparing the dynamic and thermal backgrounds of spring and summer events.*

Location in revised manuscript: *Sect. 2.3, anomaly calculation method*

Original text: *The original manuscript did not clearly explain how "anomalous" fields were calculated.*

Revised text: *For each dust-storm event and each lead time relative to storm onset, the corresponding 2024 ERA5 value was extracted. The background value was calculated from ERA5 records during 2015–2025, excluding 2024, using the same hour of the day within a ±3-day calendar window. The* *anomaly was then obtained by subtracting this background value from the corresponding 2024 event value. Area-mean values were calculated using latitude-weighted averaging with cos(latitude) as the weight.*

Reason for this revision: *The anomaly calculation is now reproducible and supports the new quantitative diagnosis.*

Location in revised manuscript: *Sect. 3.3, Fig. 10 analysis*

Original text: *The original Results relied on maps and variance/range tables, for example the interpretation that the pressure difference between ΔP12h and ΔP6h showed the most pronounced fluctuation and could represent key prediction windows.*

Revised text: *Figure 10 was added to show the composite evolution of dynamic and thermal anomalies from −24 to +3 h relative to dust-storm onset. The revised text states that the mean sea-level pressure-gradient anomaly and 850 hPa height-gradient anomaly remain higher in spring throughout the pre-onset period, while the 10 m wind-speed anomaly increases more sharply near onset.*

Reason for this revision: *The revised analysis provides quantitative evolution curves rather than relying only on visual map comparison or variance-table interpretation.*

Location in revised manuscript: *Sect. 3.3, thermal diagnostics*

Original text: *The original text inferred summer thermal dominance mainly from temperature maps and qualitative discussion of surface heating and convection.*

Revised text: *The revised text states that, in summer, the net shortwave-radiation anomaly is strongly positive during the early pre-onset stage, the surface–air temperature-difference anomaly is also positive before about −18 h, and the boundary-layer-height anomaly reaches approximately 200–300 m.*

Reason for this revision: *These indicators provide more direct quantitative support for early thermal preconditioning before summer events.*

Location in revised manuscript: *Abstract and Sect. 5 "Conclusion"*

Original text: *The original manuscript stated that spring dust storms are dominated by dynamic factors, summer storms are influenced by thermal factors, and significant changes 12–6 h before storms provide a critical prediction window.*

Revised text: *The revised manuscript states that spring events were associated with stronger pressure-gradient and 850 hPa height-gradient anomalies, while summer events showed weaker pressure-*

gradient signals but stronger early thermal anomalies. The 12–6 h key-prediction-window statement was removed.

Reason for this revision: *The conclusions are now framed as suggestive observational evidence rather than as a validated predictive rule.*

Comments 3

Reviewer comment: The paper attributes summer dust storms to stronger surface-atmosphere temperature contrasts, convection, and vertical motions, and discusses terrain effects on vertical and horizontal dust fluxes. These ideas are plausible, but they are not supported by direct analysis of quantities that would better establish the proposed mechanisms, such as vertical velocity, boundary-layer depth, turbulent mixing, instability indices, or a more formal decomposition of forcing terms. In several places, the manuscript presents interpretations as conclusions even though they are more appropriately framed as hypotheses.

Response: *Thank you for this insightful comment. We agree that the previous version interpreted convection, vertical motion, and terrain-related flux mechanisms too strongly. We revised the manuscript in three ways: we added boundary-layer height to the ERA5 thermal diagnostics, replaced the flux-centered results with directly observed wind and temperature anomaly profiles, and softened unsupported mechanistic wording. We also added a limitations paragraph acknowledging the lack of direct turbulence, vertical velocity, and lidar observations.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Sect. 2.3 and Sect. 3.3, boundary-layer diagnostic*

Original text: *The original manuscript discussed thermal instability and vertical motion but did not include a boundary-layer-depth diagnostic in the quantitative analysis.*

Revised text: *Boundary-layer height was added as one of the thermal indicators, and Fig. 10 now includes boundary-layer-height anomalies together with surface–air temperature difference and net shortwave radiation.*

Reason for this revision: *The added BLH diagnostic gives a more appropriate basis for discussing thermal preconditioning and boundary-layer development.*

Location in revised manuscript: *Sect. 3.2 "Dust Storm Dynamic and Thermal Meteorological Background"*

Original text: *The original text stated that the land–atmosphere temperature difference caused warm air to rise, generated strong winds, and triggered dust storms.*

Revised text: *The revised text states that stronger surface heating "may have enhanced the surface–air temperature difference, promoted boundary-layer development, and provided favorable thermal conditions for dust mobilization."*

Reason for this revision: *The revised wording avoids presenting unmeasured convection and vertical motion as direct conclusions.*

Location in revised manuscript: *Sect. 3.3, interpretation of summer thermal processes*

Original text: *The original text stated that summer dust storms were mainly influenced by surface–atmosphere temperature differences and intense instability.*

Revised text: *The revised text states that summer thermal forcing "mainly provided early preconditioning" and that final onset still required near-surface wind enhancement.*

Reason for this revision: *This revision makes the mechanism interpretation more balanced and avoids overattributing onset to thermal forcing alone.*

Location in revised manuscript: *Sect. 3.4 title and content*

Original text: *The original main analysis focused on horizontal dust flux (Q), vertical dust flux (F), and their terrain-dependent differences.*

Revised text: *Sect. 3.4 was revised as "Tower-observed wind and temperature anomaly profiles". The new analysis focuses on 10 m wind-speed anomaly, 2–10 m wind-shear anomaly, 0.5–10 m air-temperature-difference anomaly, 2 m air-temperature anomaly, and vertical profiles of wind-speed and air-temperature anomalies.*

Reason for this revision: *The revised section is based on directly observed meteorological variables and avoids overinterpreting flux mechanisms without uncertainty assessment.*

Location in revised manuscript: *Sect. 4 "Discussion", limitations paragraph*

Original text: *The original Discussion did not sufficiently acknowledge missing diagnostics for vertical transport processes.*

Revised text: *The revised Discussion states that "the lack of direct turbulence, vertical velocity, and lidar observations limits the interpretation of vertical transport processes" and suggests combining multi-year observations, turbulence measurements, lidar data, and high-resolution simulations in future work.*

Reason for this revision: *The limitations now clearly distinguish supported results from mechanisms that require further testing.*

Comments 4

Reviewer comment: HYSPLIT interpretation: The paper classifies dust trajectories into three pathway types using HYSPLIT and ERA5 wind fields. However, the manuscript itself notes that the station-based backward trajectories cannot fully represent wind direction and sources across the full desert region. This limitation is important because air-mass back trajectories do not automatically identify true dust source regions or emission processes, especially over complex terrain. The pathway classification should therefore be presented more cautiously.

Response: *Thank you for this important comment. We agree that HYSPLIT backward trajectories should be interpreted cautiously, especially over complex terrain. We revised the manuscript to describe the trajectories as pre-storm airflow histories or airflow transport pathways reaching the observation region, rather than as direct evidence of dust source regions or emission processes. We also clarified the model settings and used ERA5 10 m wind fields only as supporting regional context.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Sect. 2.4 "HYSPLIT Model"*

Original text: *The original text stated that HYSPLIT was used to analyze the transport pathways of each dust storm event, but the model settings and interpretive limits were insufficiently specified.*

Revised text: *The revised section states that the simulations used GDAS1 data at 1° × 1° and 3 h resolution, with model vertical velocity for vertical motion calculation. Backward trajectories were initialized at dust-storm onset, the endpoint was set at 39.43° N, 85.97° E, starting heights were 100, 500, and 1500 m AGL, and each trajectory was traced backward for 48 h.*

Reason for this revision: *The HYSPLIT procedure is now reproducible and more clearly limited to airflow-pathway interpretation.*

Location in revised manuscript: *Sect. 2.4, interpretation sentence*

Original text: *The original manuscript included wording that could be read as tracing dust sources directly.*

Revised text: *The revised text states: "The resulting trajectories were used to characterize the main pre-storm airflow histories reaching the observation region and to support the interpretation of airflow transport pathways together with ERA5 10 m wind fields."*

Reason for this revision: *This sentence clarifies that the trajectories indicate airflow histories, not direct dust-source attribution.*

Location in revised manuscript: *Sect. 3.1 "Dust Storm Trajectory Analysis"*

Original text: *The original text described the HYSPLIT results as "dust trajectories" and stated that HYSPLIT reveals "dust source trajectories passing through the stations".*

Revised text: *The revised text states that the analyzed dust-storm events were associated with three main types of "pre-storm airflow transport pathways": east-inflow transport, south-to-north pathway, and northwestern transport/mountain-crossing airflow.*

Reason for this revision: *The revised wording separates air-mass pathway information from dust-emission/source identification.*

Location in revised manuscript: *Sect. 3.1, ERA5 support statement*

Original text: *The original manuscript stated that ERA5 wind maps could reveal anomalous wind speeds corresponding to HYSPLIT and provide a more comprehensive data basis for dust trajectory analysis.*

Revised text: *The revised text states that ERA5 10 m wind fields provide regional support for the trajectory results and that these results suggest the analyzed events were influenced by multiple airflow pathways.*

Reason for this revision: *The ERA5 fields are now presented as contextual support rather than independent proof of source attribution.*

Location in revised manuscript: *Sect. 5 "Conclusion"*

Original text: *The original Conclusion stated that dust-storm trajectories in the TD can be classified into three types.*

Revised text: *The revised Conclusion states that the analyzed events exhibited three main types of pre-storm airflow transport pathways.*

Reason for this revision: *The revised wording is more cautious and matches the limitations of station-based backward trajectories.*

Comments 5

Reviewer comment: The study's conclusions about differences in horizontal and vertical dust flux between the two sites are potentially interesting, but the manuscript does not adequately discuss uncertainty, observational error, sampling representativeness, or sensitivity of the flux calculations to assumptions in the method. Since the flux results are central to the paper, this omission weakens the reliability of the interpretation.

Response: *Thank you for this important comment. We agree that the previous flux-centered analysis did not sufficiently discuss uncertainty, observational error, sampling representativeness, or sensitivity* *to methodological assumptions. To avoid overinterpreting uncertain flux estimates, we removed the flux-centered analysis from the main Results and Conclusion. The revised manuscript instead focuses on tower-observed wind-speed, wind-shear, and temperature anomaly profiles, which are more directly supported by the available gradient-tower observations.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Abstract*

Original text: *The original Abstract included horizontal dust flux (Q) and vertical dust flux (F) as central findings, including statements about Q patterns at Xiaotang and terrain effects at Tazhong.*

Revised text: *The revised Abstract no longer presents Q/F flux conclusions. It focuses on airflow pathways, ERA5 dynamic and thermal anomaly diagnostics, and tower-observed warming, wind-speed, and wind-shear enhancement.*

Reason for this revision: *The Abstract now reflects the revised evidence base and avoids unsupported flux-centered conclusions.*

Location in revised manuscript: *Keywords*

Original text: *The original keywords included "Horizontal And Vertical Dust Flux Analysis".*

Revised text: *The revised keywords are: Dust storm; Taklimakan Desert; HYSPLIT; ERA5; dynamic and thermal anomalies; vertical observation.*

Reason for this revision: *The keywords were aligned with the revised focus of the manuscript.*

Location in revised manuscript: *Sect. 2.2 "Observational Data"*

Original text: *The original text stated that the gradient collection system was used to determine horizontal dust flux at different heights.*

Revised text: *The revised text states that the meteorological gradient observations were mainly used to examine wind-speed, wind-shear, and temperature-profile responses during dust-storm development.*

Reason for this revision: *The data-use description was revised to match the new tower-profile analysis.*

Location in revised manuscript: *Old Sect. 2.5 and old Sect. 3.4*

Original text: *The original manuscript included "2.5 The calculation of horizontal dust flux (Q) and vertical dust flux (F)" and a main Results section centered on Dust Flux Analysis.*

Revised text: *The flux-calculation section and flux-centered Results interpretation were removed from the main analysis. Sect. 3.4 was revised as "Tower-observed wind and temperature anomaly profiles".*

Reason for this revision: *This avoids presenting flux estimates as central conclusions without a full uncertainty and sensitivity assessment.*

Location in revised manuscript: *Sect. 3.4 revised Results*

Original text: *The original Results compared Q and F profiles between TZ and XT and interpreted terrain effects from flux-profile behavior.*

Revised text: *The revised Results compare wind-speed anomaly profiles and air-temperature anomaly profiles at TZ and XT. The text states that XT shows more regular vertical structures, whereas TZ profiles are more irregular and may reflect the influence of undulating dune topography and local flow disturbance.*

Reason for this revision: *The interpretation of terrain effects is now based on directly observed meteorological profile differences rather than uncertain flux estimates.*

Location in revised manuscript: *Sect. 5 "Conclusion"*

Original text: *The original Conclusion included Q/F relationships at XT and TZ and linked them to flat or undulating terrain.*

Revised text: *The revised Conclusion states that XT displayed more regular wind and temperature anomaly structures, whereas TZ showed more variable profiles, suggesting that local terrain heterogeneity may modulate the near-surface response to regional dynamic and thermal forcing.*

Reason for this revision: *The revised conclusion retains the terrain-effect discussion but avoids unsupported flux-specific claims.*

List of technical glitches and editorial problems

Comments 6

Reviewer comment: Table 1: XT(, XT), XT should be the same?

Response: *Thank you for pointing out this typographical inconsistency. We checked Table 1 and corrected station-name errors. The station names are now consistently written as TZ and XT throughout the table and the manuscript.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Table 1*

Original text: *Some station names appeared as "XT(", "XT)", "XTTZ", "TZ(", or other inconsistent forms.*

Revised text: *All station names in Table 1 were standardized as "TZ" or "XT".*

Reason for this revision: *This correction removes typographical inconsistencies and makes the table consistent with the rest of the manuscript.*

Location in revised manuscript: *Sect. 2.2 "Observational Data"*

Original text: *The original text used inconsistent naming such as "XT Station", "X Station", and station-name fragments.*

Revised text: *The revised text defines the two stations as Xiaotang (XT), located on the northern edge of the TD, and Tazhong (TZ), situated in the desert interior.*

Reason for this revision: *The station abbreviations are now defined once and used consistently.*

Comments 7

Reviewer comment: Event dates and periods are not consistent.

Response: *Thank you for this comment. We revised the Abstract, Sect. 2.2, Table 1, Results, and Conclusion to ensure consistency in event dates, event numbering, and seasonal grouping. The analyzed events are now consistently labeled as Dust1–Dust8, and the seasonal grouping is defined as spring for March–April events and summer for May–June events.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Abstract*

Original text: *The original Abstract described eight dust storms from April to June 2024 and included broader event descriptions.*

Revised text: *The revised Abstract states that the study examined eight dust-storm events in spring and summer 2024.*

Reason for this revision: *This revision avoids inconsistency between the Abstract and Table 1, because the first event started on 31 March 2024.*

Location in revised manuscript: *Sect. 2.2 "Observational Data"*

Original text: *The original text referred to observations between April 3 and July 10, 2024, which mixed event onset dates with sample-collection dates.*

Revised text: *The revised text states that nine dust-storm events were observed between 31 March and 18 June 2024, and that the corresponding dust samples were collected from 3 April to 10 July 2024.*

Reason for this revision: *The event observation period and sample-collection period are now separated clearly.*

Location in revised manuscript: *Table 1*

Original text: *The original table used mixed date formats such as 2024.3.31 and incomplete or inconsistent event labels such as Dust32, Dust43, Dust98.*

Revised text: *The revised table uses standardized date-time format (YYYY-MM-DD HH:MM), labels the final analyzed events as Dust1–Dust8, and includes one row labelled "Excluded event".*

Reason for this revision: *The table now provides a consistent basis for the Methods, Results, and Conclusion.*

Location in revised manuscript: *Sect. 3.2 and Sect. 3.3*

Original text: *The original manuscript described the spring/summer grouping after mixed references to March–June and April–June.*

Revised text: *The revised text states that the March–April events were grouped as spring cases and the May–June events were grouped as summer cases for the dynamic and thermal anomaly analysis.*

Reason for this revision: *The seasonal grouping is now consistently applied throughout the Results.*

Location in revised manuscript: *Sect. 5 "Conclusion"*

Original text: *The original Conclusion stated that eight observational samples were obtained from April to June.*

Revised text: *The revised Conclusion states that the study examined eight complete dust-storm events over the Taklimakan Desert using HYSPLIT trajectories, ERA5 reanalysis, and dual-gradient tower observations.*

Reason for this revision: *This avoids the inconsistent April–June description and uses the same sample definition as the Abstract and Methods.*

Comments 8

Reviewer comment: Station naming is not consistent throughout the manuscript.

Response: *Thank you for pointing this out. We standardized the station names throughout the manuscript. The desert-interior station is consistently referred to as Tazhong (TZ), and the northern desert-margin station is consistently referred to as Xiaotang (XT). We removed inconsistent forms such as "X Station", "XiaoTang", and typographical station-name errors in the table.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Abstract*

Original text: *The original Abstract referred generally to central and peripheral regions of the TD without clearly defining the two station names.*

Revised text: *The revised Abstract states: "dual-gradient tower observations from Tazhong (TZ) and Xiaotang (XT)".*

Reason for this revision: *The station names and abbreviations are introduced at the beginning of the manuscript.*

Location in revised manuscript: *Sect. 2.2 "Observational Data"*

Original text: *The original text used inconsistent phrases such as "Xiaotang (XT)X Station", "TZ Station", and "X Station".*

Revised text: *The revised text states: "The observational data were obtained from two stations: Xiaotang (XT), located on the northern edge of the TD, representing flat terrain, and TZ, situated in the desert interior, representing undulating terrain."*

Reason for this revision: *The station descriptions are now concise and consistent.*

Location in revised manuscript: *Table 1 and figure captions*

Original text: *The original table and captions contained inconsistent abbreviations and formatting, including station-name fragments.*

Revised text: *The revised Table 1 uses only "TZ" and "XT", and the Fig. 1 caption identifies the Tazhong (TZ) and Xiaotang (XT) observation towers.*

Reason for this revision: *The same naming system is now used in the table, captions, Results, Discussion, and Conclusion.*

Location in revised manuscript: *Sect. 3.4 and Sect. 5*

Original text: *The original text sometimes referred to flat and undulating terrain without consistently linking them to XT and TZ.*

Revised text: *The revised text states that XT displayed more regular vertical structures, whereas TZ showed more variable profiles, suggesting terrain-related modulation of near-surface responses.*

Reason for this revision: *The station-specific interpretation now uses consistent abbreviations and terrain descriptions.*

Comments 9

Reviewer comment: HYSPIT?

Response: *Thank you for identifying this spelling error. We corrected "HYSPIT" to "HYSPLIT" in the section title and throughout the manuscript.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Sect. 2.4 title*

Original text: *2.4 HYSPIT model.*

Revised text: *2.4 HYSPLIT Model.*

Reason for this revision: *The model name was corrected and capitalized consistently.*

Location in revised manuscript: *Sect. 2.4 first sentence*

Original text: *The original section title and nearby text contained the misspelling "HYSPIT".*

Revised text: *The revised text states: "The study used the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to analyze the transport pathways of each dust storm event."*

Reason for this revision: *The full model name and abbreviation are now correct and consistent.*

Location in revised manuscript: *Abstract, Keywords, Sect. 3.1, Discussion, and Conclusion*

Original text: *The original manuscript used inconsistent HYSPLIT/HYSPIT spelling in several places.*

Revised text: *All occurrences were checked and standardized as "HYSPLIT".*

Reason for this revision: *This correction removes a technical spelling error throughout the manuscript.*

Comments 10

Reviewer comment: Table 3: mislabeled?

Response: *Thank you for pointing out this problem. The previous Table 3 was mislabeled because the header referred to ΔP while the text discussed temperature differences. In the revised manuscript, the previous variance tables were removed and replaced by a composite anomaly analysis in Fig. 10. This revision avoids the inconsistency between table headers, variable names, and text interpretation.*

Detailed changes made in the manuscript:

Location in revised manuscript: *Old Table 3*

Original text: *The Table 3 title and header referred to variance and range of 24 h, 12 h, 6 h, and 3 h before the dust storm, while the column headers still included "Variance of ΔP24h", "Variance of ΔP12h", and related pressure labels even though the text discussed temperature differences.*

Revised text: *The previous Table 3 was removed from the main Results.*

Reason for this revision: *Removing the table avoids a variable-label mismatch and prevents readers from confusing pressure and temperature diagnostics.*

Location in revised manuscript: *Sect. 3.3, replacement analysis*

Original text: *The original text interpreted variance and range values from Tables 2 and 3 and used them to support the 12–6 h prediction-window statement.*

Revised text: *The revised Results instead use Fig. 10, "Composite evolution of dynamic and thermal anomalies from −24 to +3 h relative to dust-storm onset," to present the diagnostic indicators consistently.*

Reason for this revision: *The replacement figure directly matches the revised variables and provides clearer support for the dynamic–thermal comparison.*

Location in revised manuscript: *Sect. 3.3, terminology after removing Table 3*

Original text: *The original text used mixed terms such as ΔP for pressure and ΔT/temperature changes in adjacent table and figure descriptions.*

Revised text: *The revised text consistently distinguishes mean sea-level pressure-gradient anomaly, 850 hPa geopotential-height-gradient anomaly, 10 m wind-speed anomaly, surface–air temperature-difference anomaly, net shortwave-radiation anomaly, and boundary-layer-height anomaly.*

Reason for this revision: *Terminology and variables are now consistent between the text, figure captions, and revised analysis.*

Location in revised manuscript: *Sect. 5 "Conclusion"*

Original text: *The original Conclusion included the statement that the 12–6 h period before the dust storm can be used as a key time window for prediction.*

Revised text: *The revised Conclusion removes this statement and instead states that the tower observations indicate a staged process from early background adjustment to near-surface wind enhancement.*

Reason for this revision: *This avoids drawing a forecasting conclusion from a mislabeled or insufficiently validated variance-table analysis.*

Additional note

In addition to the revisions listed above, the manuscript was also revised in response to the other reviewers' comments. These additional revisions mainly include rewriting the Introduction, clarifying the methodological framework, adding ERA5-based quantitative anomaly diagnostics, defining the anomaly baseline and spatial averaging domains, adding detailed HYSPLIT settings, revising figure captions and terminology, removing unsupported flux-centered interpretations, and adding a limitations and outlook paragraph. We believe that these revisions have improved the clarity, reproducibility, and scientific rigor of the manuscript.

Mainly Added and Revised Figures and Tables

Table 1. Summary of observed dust-storm events and sample collection information

Event ID	Station	Start time of dust storm	Duration (h)	Sample collection time
Dust1	TZ	2024-03-31 12:00	22	2024-04-01 09:00
	XT	2024-03-31 12:40	17.3	2024-04-01 06:00
Excluded event	XT	2024-04-05 01:00	5	2024-04-05 06:00
Dust2	XT	2024-04-12 04:00	7.5	2024-04-12 14:00
	TZ	2024-04-14 04:00	11	2024-04-14 15:00
Dust3	XT	2024-04-17 11:00	23	2024-04-18 10:00
	TZ	2024-04-18 10:00	36	2024-04-19 22:00
Dust4	TZ	2024-04-26 21:00	16.5	2024-04-27 13:30
	XT	2024-04-26 02:00	31	2024-04-27 09:00
Dust5	TZ	2024-05-12 07:00	24	2024-05-12 14:30
	XT	2024-05-12 07:30	7	2024-05-12 14:30
Dust6	TZ	2024-05-20 11:00	14	2024-05-20 14:30
	XT	2024-05-20 11:00	3.5	2024-05-20 14:30
Dust7	TZ	2024-06-04 04:00	12	2024-06-04 16:00
	XT	2024-06-04 04:00	3	2024-06-04 07:00
Dust8	TZ	2024-06-18 07:00	2	2024-06-18 09:00
	XT	2024-06-18 07:20	3.7	2024-06-18 11:00

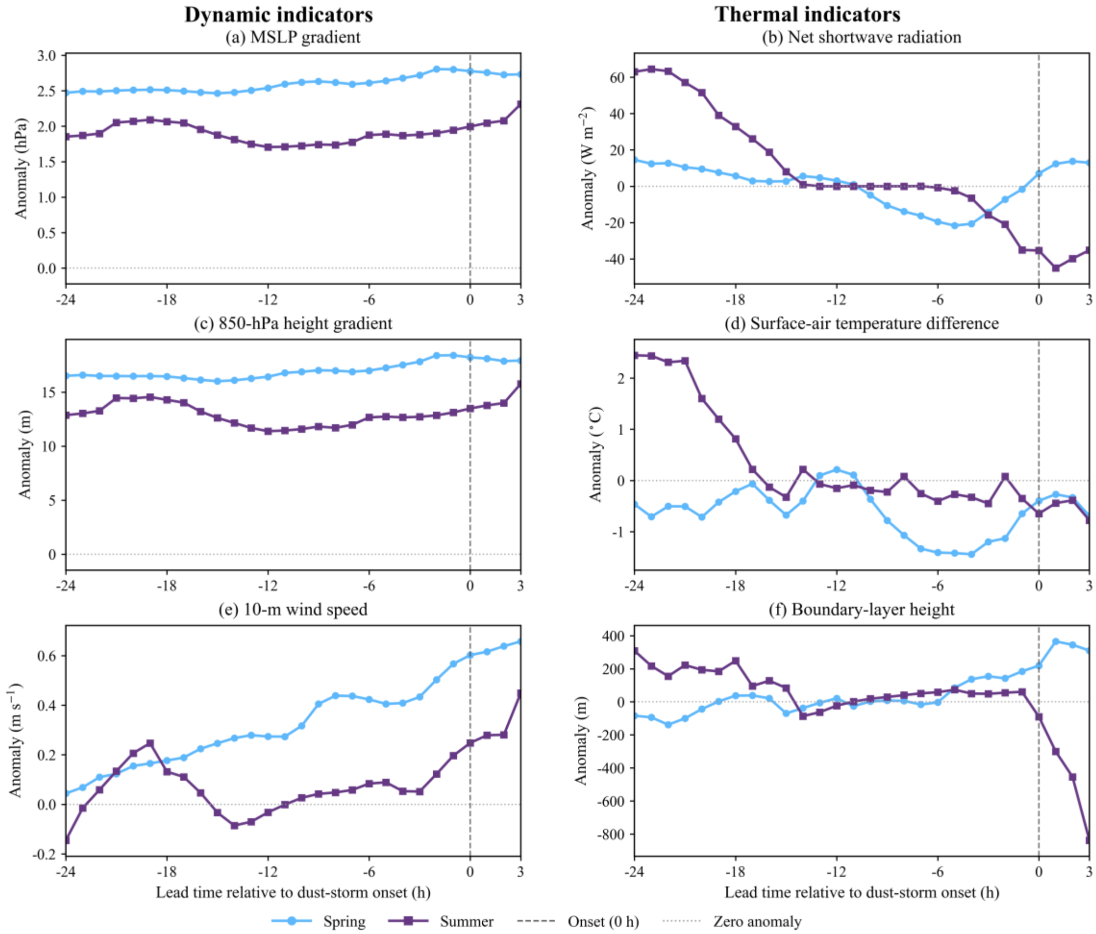

Fig. 10. Composite evolution of dynamic and thermal anomalies from −24 to +3 h relative to dust-storm onset.

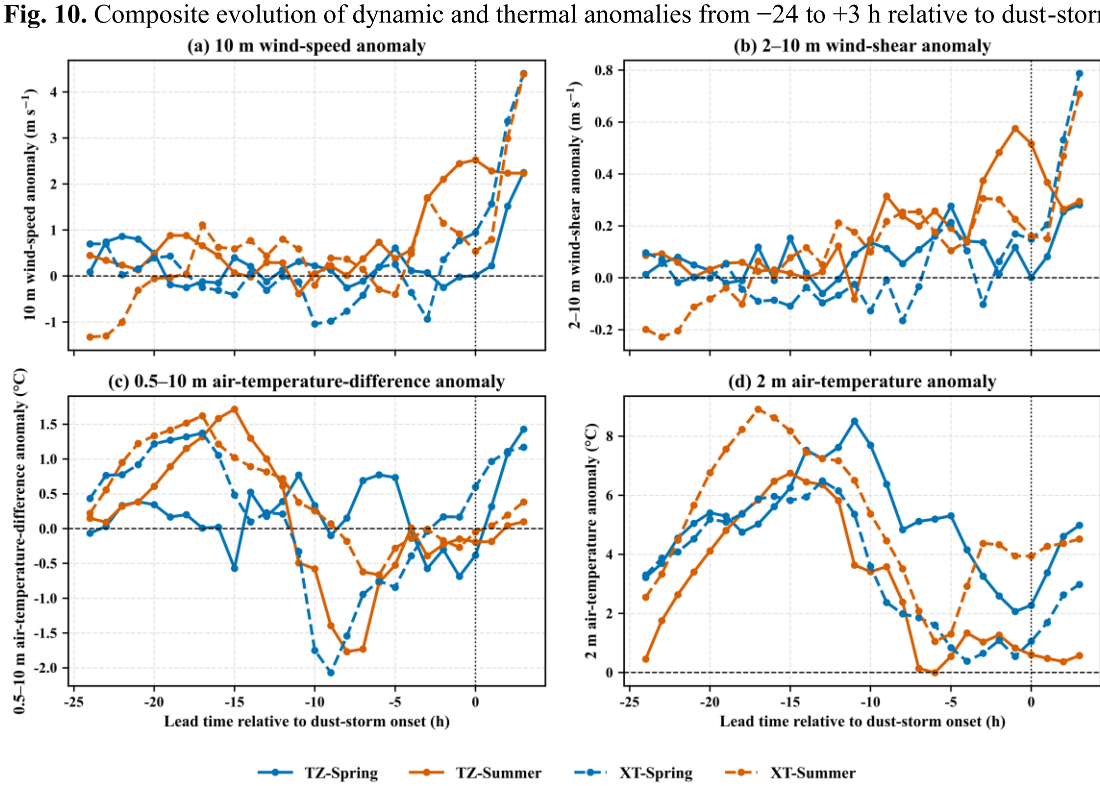

Fig. 11. Composite evolution of tower-observed wind-speed, wind-shear, air-temperature-difference, and 2 m air-temperature anomalies from −24 to +3 h relative to dust-storm onset.

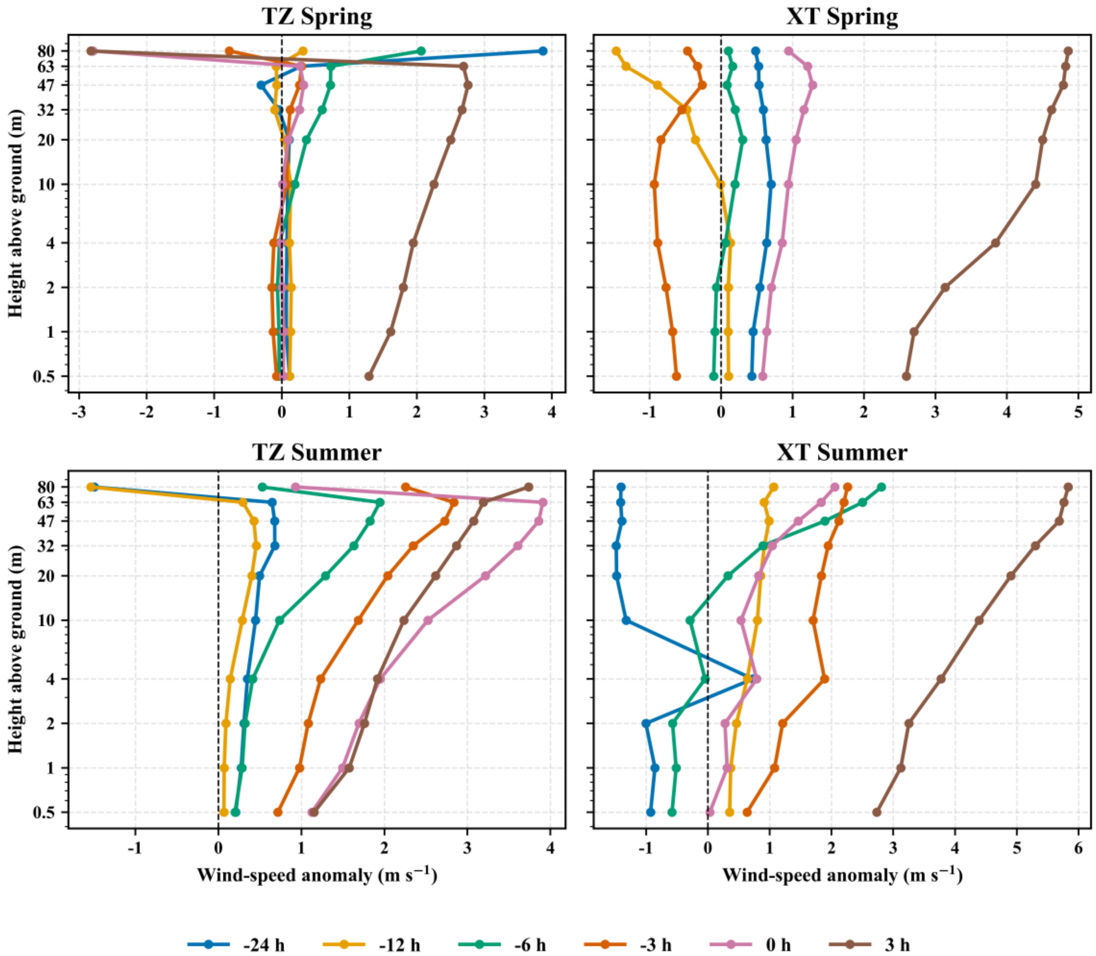

Fig. 12. Vertical profiles of wind-speed anomalies at TZ and XT during spring and summer dust-storm events.

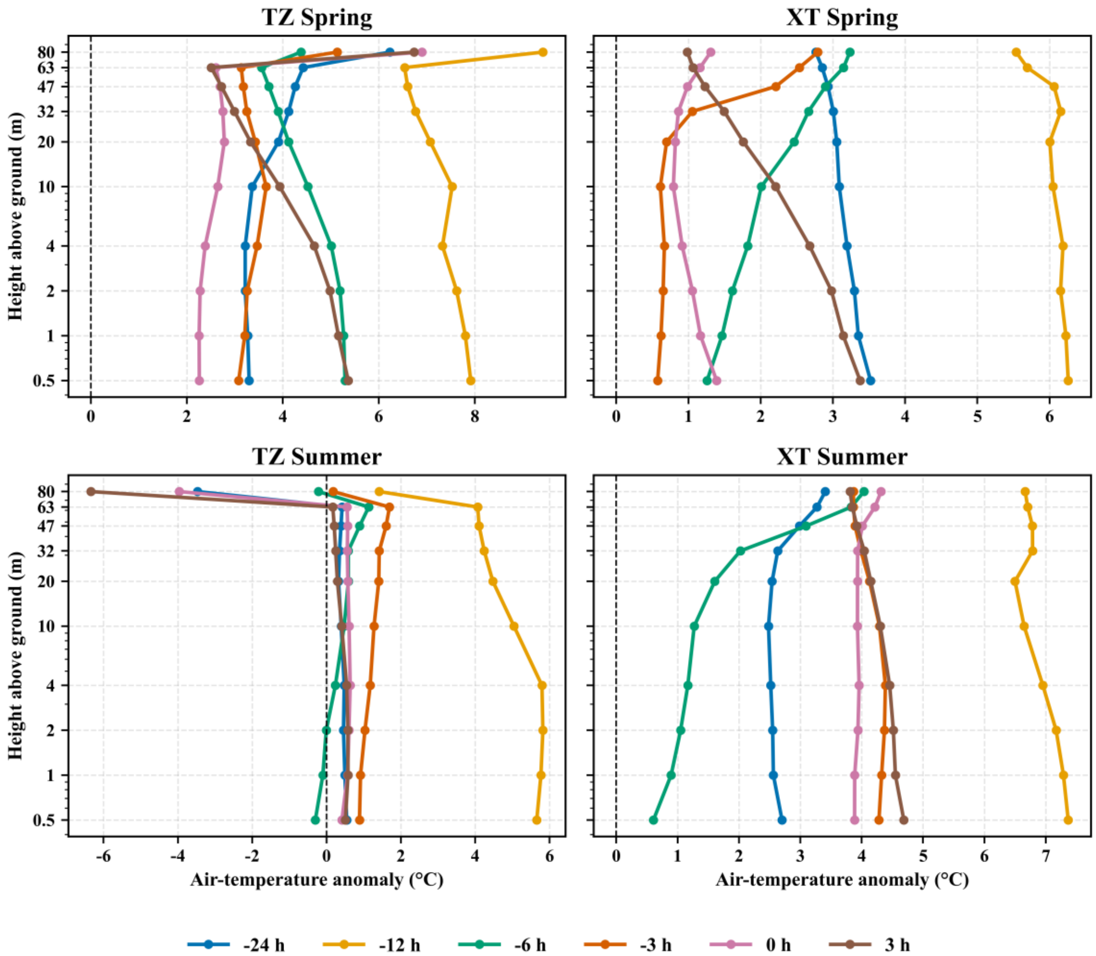

Fig. 13. Vertical profiles of air-temperature anomalies at TZ and XT during spring and summer dust-storm events.