To: The Editors and Reviewers

Subject: Re: Point-by-Point Response to Reviewers' Comments on Manuscript [egusphere-2025-2012]

Dear Reviewers,

Thank you once again for dedicating your time and expertise to reviewing our manuscript. We sincerely appreciate your insightful and constructive feedback, which has been invaluable in strengthening our paper. We have thoroughly considered all points raised and have revised the manuscript accordingly. Below, we provide a point-by-point response to your comments. Below we respond to all referee comments (RCs) provide a detailed point-by-point response (in Blue purple) to the reviewers' comments (in Black).

Response to Report#1's comments

General Comment:

Rereview of Development and application of the Ascent-Drift-Descent Radiosonde System (ADDRS) by Cao et al

January 2026

General

This manuscript describes a major ongoing/forthcoming change to Chinese operational radiosondes and a novel three-phase measurement pattern (I'm not sure whether other operators will try that pattern). It would be very helpful to understand the phase out of the old Chinese radiosondes and the phase in of the new. The WMO BUFR code includes 'radiosonde type', in December 2025 we saw small numbers of the old radiosonde types (200, 201 and 202), but the vast majority of Chinese reports had the radiosonde type set to missing which is not helpful. We saw ascent profiles, but no Chinese descent profiles. Some information on the progress/plans for the transition would be very useful. The manuscript has been improved and contains a lot of good information. As with the previous review some issues mentioned in the authors response should be included in the main manuscript, notably in the discussion of the drift and descent phases.

Authors: We thank the reviewer for recognizing the significance of the work and for the valuable suggestions regarding the operational transition.

We acknowledge the points raised concerning WMO BUFR reporting and the current lack of descent profiles in operational data streams. The transition of the CMA's national upper-air observation network is a key context for this discussion.

Instrumentation Transition and Code Updates: The CMA completed the nationwide upgrade of its 131 operational radiosonde stations in October 2025, transitioning from the legacy L-band radar system to a new generation of Beidou-based systems. Correspondingly, the WMO instrument codes in use have been updated: The legacy codes 200, 201, 202, and 203 correspond to the previous L-band sondes (GTS11, GTS12, GTS13, GTS14 models) and are now only used at a very limited number of stations for specific wind observations, explaining their minimal presence in the data stream. The new Beidou-based sondes, including the ADDRS types, have been assigned the official codes 204 through 209 (corresponding to GTH1 to GTH6 models), as published in the WMO Manual on Codes(WMO-No. 306, 2025 edition), Common Code Table C-2.

Current Status and Future Plans: We also acknowledge and thank the reviewer for identifying an initial oversight: the instrument code in the BUFR reports was not updated promptly during the initial transmission of Beidou ascent data in October. This issue has been corrected (instrument types from missing to the new (204-209)) on 26 January 2026. Concerning the reporting of new data types (including descent profiles), the development and deployment of the necessary technical standards and reporting workflows are underway. We expect this work to be finalized and operational by 2027.

We agree that these operational details provide important context. Key points from this explanation have been integrated into the main text of the revised manuscript (Lines 213-215).

Specific Comments:

Comment 1. Drift phase: reporting issues and the quality of winds

The author response states that:"Sensor Response and Balloon Dynamics:Under the relatively calm conditions of the drift phase, the radiosonde's motion can be more susceptible to fine-scale turbulence and the pendulum motion of the radiosonde suspended under the balloon. This can potentially add high-frequency noise to the wind measurements that is not representative of the synoptic-scale flow the model resolves."

The authors suggest that they have addressed these issues in the discussion section - I *struggle to see where (there are only two instances of "pendulum" and two of "turbulence" in the revised manuscript, none of these in the context of the drift phase). NB The track check document shows all changes since the original submission, it should just show the changes in the latest revision to make it more useful.*

IF there is evidence of more pendulum motion during the drift phase then it should be presented in the main manuscript. [Note to ADDRS research team. You might want to consider adding a (small, cheap) accelerometer to your radiosonde. I have spoken to some of the authors of the paper below and they agree that accelerometer output could be used to improve the filtering of pendulum motion. Marlton GJ, Harrison RG, Nicoll KA, Williams PD. 2015 A balloon-borne accelerometer technique for measuring atmospheric turbulence. Rev. Sci. Instrum. 86, 016109. doi:10.1063/1.4905529]

Also in the author response:"If the drift phase is too long, the data may become obsolete for the intended assimilation cycle."

"Challenges in Data Assimilation: Standard data assimilation systems, including the one used in this study, are primarily optimized for conventional, quasi-vertical profiles. The assimilation of observations with significant horizontal drift presents a more complex challenge for the observation operator, which typically assumes the observation is located at a single horizontal point. This mismatch can contribute to the increased errors seen in Table 5."

Some NWP systems now allow for horizontal drift in their processing of ascents (and descents), see Pauley and Ingleby (2022), figure 7 and associated text. This improves the fit between observations and model background in the stratosphere. (Probably worth mentioning this and the reference in main text.) The ECMWF system splits BUFR profiles into 5 (originally 15) minute sub-profiles and treats the sub-profiles as vertical, but other methods are also in use. For WindBorne both NCEP and ECMWF treat the data as a series of single-level points (like aircraft data). This raises questions about how the "drift" phase of ADDRS data should be reported and used. To me it makes sense if there is some 'batching' of the reports, but there is no need to wait for the descent to start before sending earlier parts of the drift phase. The comment about the "mismatch" above seems to suggest that the whole drift phase is being compared with model fields at a single latitude/longitude - which would indeed add (unnecessary) representation error. These issues and the processing used in your study should be discussed in the main text.

Pauley P, Ingleby B (2022) Assimilation of in-situ observations. In: Park SK, Xu L (eds) Data Assimilation for Atmospheric, Oceanic and Hydrologic Applications (Vol.

IV). Springer. https://link.springer.com/book/10.1007/978-3-030-77722-7

Authors: We thank the referee for these detailed and insightful comments regarding the drift phase, *"3)authors haven't really responded to my questions about the drift phase: the main considerations determining how long it is. There is also the question of whether 'drift' data are good enough to be used in NWP, it seems not for temperature (expected) but to my surprise the wind results (table 5) also appear worse than the ascent/descent winds - it would be very useful to understand this better."* Upon re-evaluation by the ADDRS research team, we acknowledge that our previous response contained an inaccuracy. We retract the statement suggesting that "sensor response and balloon dynamics" during the calm drift phase add significant high-frequency noise to wind measurements. We apologize for this error and provide a corrected, in-depth analysis below to address the core issues: the interpretation of the drift wind phase seemingly larger wind differences (e.g., in Table 5) compared to ascent/descent data. (please see Section 4.2, on page 15, Lines 385-389) to clarify our methodology and provide a more accurate and complete picture of the associated challenges.

1. Re-analysis of the Differences in Wind Data

The observed U/V wind component differences between our high-resolution drift-phase observations and reanalysis (e.g., ERA5) likely stem from a combination of the following three factors, with the latter two being predominant:

1.1. Data Processing and Quality Verification of the Drift-Phase Winds

(1) To validate the reliability of the ADDRS wind data and investigate potential processing deficiencies, we implemented a comprehensive quality control scheme specifically designed for the drift phase. The results confirm the high reliability of the drift-phase wind observations.

This conclusion is strongly supported by dedicated Balloon-borne Radiosonde Angular Motion Experiments conducted in August 2023 at the Xilinhot GRUAN site. The core objective was to directly observe the in-flight motion dynamics of the radiosonde. The methodology involved a modified GTH3 radiosonde integrated with an attitude sensor package (axial accelerometer and gyroscope, based on principles similar to Marlton et al., 2015). This setup enabled direct observation and quantification of the radiosonde's pendulum motion. A total of eight successful field launches were performed. The attitude sensors recorded raw axial acceleration and angular velocity data at 1 Hz throughout the entire flight.

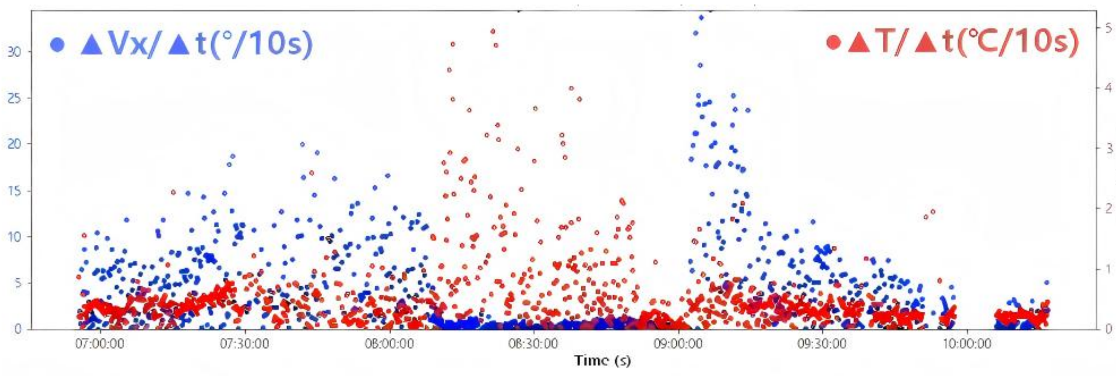

Fig.R1 the relationship between temperature gradient throughout the entire phase of ADDRS balloon with 30 meters string length and the rate of change in Vx (Angular Rate) attitude

(2) Evidence of less pendulum motion during the drift phase: The data confirmed the attenuated pendulum motion during the stable drift phase. Specifically, when the system transitions from ascent to stable drift (Fig.R1 about 08:15:00), the angular rate decreases significantly and the pendulum amplitude decays rapidly. Data analysis revealed that during ascent and descent, the rate of attitude change (e.g., angular velocity) is high while the rate of temperature change is low. Conversely, during the drift phase, the rate of temperature change is relatively high while the rate of attitude change is minimal. This physical understanding validates the basis for applying a smaller filter window during the calm drift phase in our data processing.

(3) Filter window length: After acquiring the raw data, the key step was to extract the effective wind speed calculation information representing the radiosonde's horizontal motion, which required filtering out high-frequency noise caused by balloon and string length swing. Tailored to the motion characteristics of the balloon during the drift phase (quasi-hydrostatic balance vertically, horizontally driven by the wind field, with rapid decay of pendulum motion upon reaching stability), a specific filtering and smoothing procedure was adopted. This method is based on a weighted moving average. Its core principle is to scientifically determine the filter window length based on the pendulum motion frequency of the radiosonde, calculated using the formula $N = 0.443 \times fs / fc$ (where fs is the sampling frequency and fc is the cut off frequency, Based on the physical characteristics of drift phase flight (such as Fig.R1 reduced pendulum motion). A weighted moving average filter was applied to smooth the raw acceleration sequence. This method effectively suppresses high-frequency oscillations, extracting the low-frequency motion trend driven by the real atmospheric wind field.

(3) Determination and Physical Interpretation of the Filter Window: The choice of filter window length directly affects the balance between signal fidelity and noise suppression. Based on the analysis of the physical characteristics of the sounding process, we established differentiated typical filter windows for different flight phases, Ascent Phase: The balloon traverses the troposphere where atmospheric turbulence is relatively strong, and its inflation and non-vertical ascent path cause more significant

radiosonde swing. To effectively smooth this relatively high-frequency swing noise, a larger filter window was chosen, with a typical value of about 30 data points (corresponding to a time scale of ~30 seconds). Drift Phase: The balloon enters the relatively stable stratosphere, drifting in a quasi-horizontal attitude. During this phase, the radiosonde's swing is significantly attenuated. Therefore, to maximize the retention of details in real wind field variations while filtering out residual minor fluctuation, a smaller filter window was adopted, with a typical value of about 15 data points (corresponding to a time scale of ~15 seconds). This effectively filters out high-frequency swinging noise to extract the true wind field information.

(4) Quality Verification and Uncertainty Assessment: Lacking a direct ground-truth reference system for the drift phase, we employed an innovative evaluation method based on an internal consistency check. The core premise assumes minimal change in the stratospheric wind field over a short period (between the ascent and drift sampling intervals). Under this premise, the technically mature ascent-phase wind data (with a known uncertainty of 0.5 m/s) was used as a reference. The wind component data from the drift phase at identical altitudes were compared for consistency. The uncertainty of the drift-phase data was evaluated through statistical analysis of a large dataset (a total of 235 ADDRS drift profiles from six stations in the middle and lower reaches of the Yangtze River in October 2019, with each profile containing over 10,000 seconds of drift phase data). The verification results show good consistency between the wind speed measurements from the drift phase and the reference data from the ascent phase. Using the consistency check standard of k=1(significance level 32%), when the pre-estimated uncertainty for the drift-phase wind components was set at 3 m/s, the probabilities of the east-west and north-south wind component differences passing the test were 27.70% and 31.66%, respectively, both within a reasonable range. Consequently, the synthesized evaluation yields a combined standard uncertainty for the wind velocity vector in the drift phase of≤3 m/s.

(5) **Conclusion:** In summary, these experiments not only successfully implemented direct attitude observation based on accelerometer but also, through the analysis of kinematic characteristics across different flight phases, provided a physical basis for the key parameter (filter window) in data post-processing. This established the differentiated filtering strategy of "larger window (~30) for the ascent phase and smaller window (~15) for the drift phase", laying a methodological foundation for accurately retrieving wind field information from raw acceleration data.

1.2. Spatio-temporal Matching and Resolution Discrepancies

A portion of the difference originates from inherent resolution mismatches in the data comparison process. Our drift-phase observations are minute/second-level data along a trajectory, while the ERA5 reanalysis has a 1-hour temporal and ~0.25° horizontal resolution. In our evaluation for Table 5 is according four stations in Guangdong (WMO: 59280, 59316, 59663, 59293) over one month (January 2024), we interpolated ERA5 pressure-level data to the radiosonde’s spatiotemporal position using bilinear (horizontal), cubic spline (vertical), and linear (temporal) interpolation.

Despite this careful matching, some expected discrepancies arise from the fundamental misalignment of the sampling characteristics, which directly inflates the representation error in a point-to-grid comparison.

1.3. Inherent Uncertainties and Limitations of the ERA5 Reanalysis in the Stratosphere

The differences also reflect known systematic limitations in ERA5's stratospheric wind field representation, rooted in the global scarcity of high-resolution direct wind observations at these altitudes.

Primary Data Sources: In the lower-to-middle stratosphere, ERA5’s wind analysis heavily relies on sparse direct observations from radiosondes (RAOB) and aircraft (AMDAR) at standard levels, exchanged via the WMO Global Telecommunication System (Hersbach et al., 2020). Satellite data provide mainly an indirect constraint on winds.

Documented Uncertainty and Limitations: ERA5’s official validation states a typical zonal wind uncertainty of ±2 m/s in the stratosphere, increasing to ~±5 m/s near 8 hPa (Hersbach et al., 2020). Independent studies confirm that localized biases can be larger in dynamically complex regions like the QBO shear zones due to insufficient representation of wave processes (Ern et al., 2023). This indicates ERA5 provides a dynamically smoothed state estimate that may struggle to capture sub-synoptic-scale, short-lived processes (Kawatani et al., 2022), which our high-resolution drift observations are designed to detect.

Therefore, discrepancies exceeding ERA5's documented error range are dynamically plausible. This highlights the value of our observations for revealing fine-scale structures and suggests that future reanalysis systems (e.g., ERA6) could benefit from assimilating such data.

Key Reference List:

Ern, M. et al. (2023). The quasi-biennial oscillation (QBO) and global-scale tropical waves in Aeolus wind observations, radiosonde data, and reanalyses. Atmos. Chem. Phys., 23, 9549–9583. (Support: Error amplification in complex regions)

Fujiwara, M. et al. (2017). Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems. J. Geophys. Res. Atmos., 122. (Support: Systematic assessment of reanalysis uncertainties in the stratosphere)

Hersbach, H. et al. (2020). The ERA5 global reanalysis. Q. J. R. Meteorol. Soc., 146, 1999–2049. (Support: Official error ranges, assimilation observation sources)

Kawatani, Y. et al. (2022). The representation of the tropical stratospheric zonal wind in global atmospheric reanalyses. J. Clim., 35, 3529 – 3552. (Support: System limitations, directions for improvement)

SPARC (2017). SPARC Reanalysis Intercomparison Project (S-RIP) Final Report.WCRP Report. (Support: Challenges of the stratospheric observation network)

In summary, the larger O-B differences for drift-phase winds (Table 5) are interpreted not as an indicator of poor data quality but primarily as a consequence of: (1) The quality verification confirms the drift-phase wind data (uncertainty ≤ 3 m/s); (2) increased representation error due to the ADDRS observation geometry mismatching the columnar assumption of standard assimilation; (3) the inherent smoothing and uncertainties of the reanalysis itself in the stratosphere.

2. Implications for Data Assimilation and Future Work

Thank you for the insightful suggestions regarding the discussion on the assimilation of drift-phase observations. We have revised the relevant section in the manuscript (please see Section 5.2, on page 17, Lines 442-449).

2.1. Development of a Trajectory-Aware Observation Operator:

We agree that the core issue is the need to treat drift-phase data according to its precise spatio-temporal location rather than as a vertical profile at a fixed point. In response to your comment and in line with recommendations from the literature (e.g., Pauley and Ingleby, 2022), we acknowledge that the traditional radiosonde observation operators used in the CMA-GFS 4DVar and CMA-MESO 3DVar systems are not suitable for assimilating trajectory-based observations like those from the ADDRS drift phase. Therefore, we are actively developing a new observation operator that accurately accounts for the exact position of each sounding measurement along its path. This work has been underway since 2025.

2.2. Revised Focus on Key Assimilation Challenges:

While the development of this new operator is essential, we agree that it is not the only, nor perhaps the most immediate, challenge for operational assimilation. Based on your feedback, we have refocused the discussion on two more pressing practical issues that currently limit the positive impact of drift-phase data:

Large Warm Bias in Daytime Temperature Observations: This bias significantly degrades the quality of temperature data during the drift phase and poses a major challenge for effective assimilation.

Observation Error Correlation and the Need for Thinning: The drift-phase observations have very high horizontal resolution (adjacent measurement points are only ~100 meters apart along the trajectory), which is much finer than the model grid resolution (~1-10 km). This leads to strong error correlations between nearby observations, an effect not accounted for in current operational observation error covariance matrices. To improve assimilation efficacy, intelligent thinning (sparsification) of the dense drift-phase data is necessary.

We believe this revised discussion provides a clearer and more comprehensive background for understanding the specific challenges and future optimization pathways for assimilating ADDRS data. Thank you for prompting this important clarification.

This insight points directly to the assimilation challenge. The core issue is that the drift-phase observation represents a spatially averaged measurement along a trajectory, whereas current operational assimilation systems (including CMA-GFS 4DVar) use observation operators designed for quasi-vertical profiles at fixed locations. To fully exploit the unique value of ADDRS and similar drift observations, future work must focus on developing trajectory-aware observation operators. Additionally, we recognize that optimizing the assimilation of drift data also requires addressing the warm bias in daytime temperature observations and the challenges of observation error correlation and data thinning. Research and development on these fronts are now underway within our group.

We thank the reviewer for prompting this much clearer and more rigorous analysis, which we have incorporated into the revised manuscript to strengthen the discussion.

2.3. Regarding data reporting strategies ("batching"):

Your reference to advanced methodologies is highly relevant. We acknowledge that our current "batching" method (treating the full drift as one profile) is suboptimal and needs refinement to minimize this error. For effective operational use, the ADDRS drift trajectory should be processed similarly to the methods you cited: by segmenting the trajectory into short-duration sub-profiles (e.g., 5-15 minutes) treated as quasi-vertical (as done in ECMWF's BUFR processing), or by treating it as a series of single-level observations along the path (analogous to how NCEP/ECMWF assimilate WindBorne or aircraft data).

Therefore, our future work — including the development of the trajectory-aware observation operator mentioned previously — will prioritize implementing such an optimized scientific segmentation or point-wise assimilation strategy. Determining this optimal processing method is logically prior to deciding on the operational data reporting strategy (e.g., batched vs. streaming, which involves trade-offs in latency and bandwidth). The technical reporting protocol can be designed once the foundational scientific processing method is established.

Finally, we sincerely thank you for your rigorous and scholarly review. Your insightful comments and questions have not only significantly improved this manuscript but have also provided excellent guidance for the China Meteorological Administration on how to better utilize novel upper-air operational data like ADDRS in the future.

Comment 2.(Use of "Pre-operational"):

' We agree that the term "a pre-operational experiment" more accurately describes the nature of our study, which was conducted to evaluate the system's performance and potential prior to its full operational deployment. As suggested, we have replaced "an operational experiment" with "a pre-operational experiment" on [Page 1, L 30] of the revised manuscript and throughout the manuscript, including in the abstract, introduction, and conclusion sections.' Searching the resubmitted manuscript only the abstract has been changed to "pre-operational".

Authors: We apologize for the oversight. We have now systematically replaced all remaining instances of "an operational experiment" with "a pre-operational experiment" or modifications throughout the main text (Line 87, Line 94, Line 114, Line 194, Line 200, Line 205, Line 265, Line 370, Line 475, Line 485) and Summary (Line 592, Line 594), not just in the abstract.

Detailed Comments (For convenience, arrange RC1 and RC2 in the same order as the lines of the entire manuscript):

We thank the both reviewers for the meticulous line-by-line corrections and suggestions. All the following points have been addressed in the revised manuscript.

1)RC1: L54-55 "radiosonde profiles still provide a crucial contribution to forecast skill and are fundamental for the calibration and validation of satellite soundings (Newman et al., 2020)." This is not a point made by Newman et al (perhaps omit that reference) and arguably the cal/val of satellite soundings would be fine with radio occultation but not radiosonde data. From my point of view the most important contribution is now in the the independent validation/verification of NWP forecasts. I suggest changing the text to:"radiosonde profiles still provide an important contribution to forecast skill, help with the calibration and validation of satellite soundings and allow independent verification of forecast fields."

Authors: We thank the reviewer for the helpful suggestion to improve clarity. The sentence at Lines 54-55 has been revised as suggested and now reads: ", radiosonde profiles still provide an important contribution to forecast skill, help with the calibration and validation of satellite soundings and allow independent verification of forecast fields."

2)RC1: 60-63 "Dropsonde data assimilation has been shown to hurricane trajectory forecast errors associated with an approximate reduction of 10-15% in specific contexts, such as short-term (0-48h) predictions over ocean basins using the GFS model, as demonstrated in multi-year statistical analyses((Ingleby, 2021; Cohn et al., 2013; Wang et al., 2015)." Grammar error, and as I said before other studies (perhaps with better use of satellite data) show much less impact, I suggest "Some multi-year studies (Cohn et al., 2013; Wang et al., 2015) suggest that assimilation of dropsonde data can reduce hurricane trajectory short-range forecast errors by 10-15%. However other studies reviewed by Majumdar (2016) show less impact." "Ingleby, 2021" is not a relevant reference here (it could be omitted from the references).

Authors: According to your suggestion Lines 60-62: The grammatical error has been corrected, and the sentence has been revised as recommended, citing Cohn et al. (2013) and Wang et al. (2015), adding the note from Majumdar (2016), and removing the Ingleby (2021) citation.

3)RC1: 68 "Johnsonet al., 2024" - "Johnson et al., 2024"

Authors: Line 67: "Johnsonet al." has been corrected to "Johnson et al."

4) RC2: l72f: Grammar error - Please rephrase the sentence starting with While early.... as:

5) RC1: 74-75 "slower ascent can reduce the accuracy of vertical resolution due to issues like sensor response time and radiative errors" slower ascent would surely increase the accuracy of vertical resolution in the case of large response time (but might make radiative errors worse)!

Authors: I agree with both reviewers opinion. The sentence has been rephrased for clarity regarding ascent rate. Lines 71-73: "Early stratospheric balloon systems encountered doubts concerning their long-term feasibility for operational data collection, attributable to cost and ascent rate limitations (WMO-No. 8., 2025). Additionally, slower ascent rates result in radiative errors issue."

6) RC1: 78-79 "Another conducted an extensive analysis by compiling four years of radiosonde data collected without parachutes across various seasons and altitudes, highlighting the scientific value of descent data (Ratnam et al., 2014; Ingleby et al., 2022)." . This conflates two different studies with different data (some of which used *parachutes). Perhaps "Studies by Ratnam et al., 2014 and Ingleby et al., 2022 looked at the quality and value of radiosonde descent data."*

7) RC2: l78f: Grammar error - please rephrase the sentence:
An extensive analysis that compiled four yearsof radiosonde data collected without parachutes across various seasons and altitudes, highlighted the scientific value of descent data(Ratnam etal., 79 2014;Ingleby etal.,2022).

Authors: The sentence has been revised as suggested to correctly describe the two studies. And We have revised the sentence as suggested: Lines 76-77: "Studies by Ratnam et al., 2014 and Ingleby et al., 2022 looked at the quality and value of radiosonde descent data."

8) RC2: l80f: On account of ... this sentence also sounds awkward. This is now the third instance, so language editing is highly recommended for the whole article.

Authors: We acknowledge the reviewer's point regarding awkward phrasing. Remove the sentence Line 79: "On account of... (Tan et al., 2006)". And we have conducted a thorough language edit of the entire manuscript to improve fluency and clarity.

9) RC2:l91ff: This innovative ... this sentence is redundant, compare with l83ff

Authors: We agree the sentence "In addition to the ascent phase of the current sounding system, ADDRS enables sounding during both the drift and descent phases. This innovative approach completes three phases of sounding with only a single balloon launch, representing a significant advancement in comparison with the traditional upper-air sounding method that has been utilized for nearly a century (Cao et al., 2022)." was redundant. It has been deleted from the Lines 80-81 of manuscript.

10) RC1: Table 1 "In the weather-sensitive area without a station, the active fusing drifting controller is carried out and the descent measurement is started" -"In a weather-sensitive area without a station, the inner balloon can be detached and the descent started"

Authors: Table 1 The text has been corrected to "In a weather-sensitive area without a station, the inner balloon can be detached and the descent started".

11)RC2: l108: The inner balloon does not burst, and the buoyancy ...
Authors: Thank you for the suggestion. The sentence on Line 100 has been revised as suggested to more accurately describe the physical process. It now reads: “The inner

balloon does not burst, and the buoyancy of the inner balloon attains equilibrium with vertical stability, starting the drift phase."

12) RC2:l112: ... begin to descend

Authors: Thank you for pointing out the grammar point in the text. We think the sentence in question ("Meanwhile, the remaining components — comprising the parachute and radiosonde—begins to descend.") was unnecessary for the description of the system's operational phases. This sentence has been deleted from the revised manuscript (Line 104). We appreciate your careful reading, which has helped to improve the conciseness and clarity of the methods description.

13) RC1: 119 "The balloon launch station" Q. Is the launched manned or automated?

Authors: We thank the reviewer for this question regarding the operational mode of the launch station. The current operational status of the ADDRS launch platform is best described as highly automated but with necessary human oversight for a critical, safety-related procedure. The core automation system handles the scheduled launch sequence, data handling, and routine operations. However, achieving a successful and prolonged drift phase-a key scientific objective of ADDRS-depends critically on the precise inflation of an inner balloonto establish neutral buoyancy. This process of achieving and verifying the exact hydrostatic balance between the inner balloon's lift and the payload weight is a complex, real-time adjustment that remains the most significant bottleneck for full, end-to-end automation. To ensure reliability and safety, this specific step currently requires trained operator supervision and manual control. We are actively working to resolve this challenge. Efforts to achieve full automation for the entire ADDRS launch process, including this critical inflation step, are ongoing and are being progressively implemented at four operational sounding stations in China. We will report on these technical advancements and their outcomes in future research updates. We have revised the relevant sentence in the manuscript Lines 109-111: "The launch station operates with a high degree of automation for scheduled sequences, though the critical procedure for inflating the inner balloon to achieve drift requires operator supervision. Full automation of this process is under active development."

14) RC1: 153 "Variations in air pressure and temperature within the outer balloon" Delete "air" (the balloon contains hydrogen).

Authors: Yes, the outside of the balloon is air, and inside it is hydrogen. This needs to be clearly distinguished throughout the text. Thank you for your careful correction. Line 143: The word "air" has been deleted.

15) RC1:204 "DdiOctyl" - " DiOctyl"?

Authors: We thank the reviewer for catching this typo. Line 194: "DdiOctyl" has been corrected to "DiOctyl".

16) RC1: 214 "The ADDRS payload unlike operational radiosonde," - "The ADDRS payload is unlike an operational radiosonde."

Authors: Thank you for highlighting the grammatical structure. Upon further consideration, we agree that the original sentence was not only grammatically imprecise but also somewhat redundant in context. Therefore, rather than rephrasing it, we have deleted the sentence from Line 204 of the revised manuscript to improve the overall conciseness of the paragraph.

17) RC1: 221-223 "Besides GTH3 ... significantly reducing" better as "Compared to the previous operational radiosonde, the GTS12 L-band Secondary Wind-sounding radar system, the GTH3 significantly reduces ..."

Authors: The sentence has been rephrased as suggested. Lines 211-213: "Compared to the previous operational radiosonde (GTS12 radiosonde, WMO BUFR code:201), the GTH3 radiosonde (WMO BUFR code:206) significantly reduce..."

18) RC1: 227 "reducing" - "reduced"

Authors: We agree with the reviewer's grammatical suggestion. it should be in the passive voice. Line 217: "reducing" has been changed to "reduced".

19) RC1: 239 "ORUC(" - "ORUC ("

Authors: We agree with the reviewer's grammatical suggestion. There is a missing space between the parenthesis and the "C". Line 229: "ORUC(" has been corrected to "ORUC (".

20) RC1: 289 "and can" - "and it can"

Authors: We agree with the reviewer's grammatical suggestion. Line 278: "and can" has been amended to "and it can".

21) RC1: 309 "Jensen et al, 2010" This is a good paper but it doesn't deal with radiosonde descent data so I am unsure or its relevance here.

Authors: We thank the reviewer for the careful reading and the insightful comment. The reviewer is correct that the cited work by Jensen et al. (2010), while valuable in its own context, does not specifically address radiosonde descent data. Upon re-evaluation, we agree that its relevance to the present discussion is limited. Therefore, we have removed this citation from the revised manuscript in Line 298 and reference. We appreciate the reviewer's guidance in helping us sharpen the focus of the references.

22) RC2: l315: ... ability to perform temporally intensive ...

Authors: We agree with the reviewer's grammatical suggestion. Line 304: The text has been corrected to: "… ability to perform temporally intensive …"

23) RC2: l322: More than ten comparative tests .... were carried out. l323: of the conical parachute

Authors: We agree with the reviewer's grammatical suggestion. Lines 308: The text has been corrected to: "More than ten comparative tests were carried out for the selection of the conical parachutes."

24) RC2: l326: The parachute area should be tailored to match the radiosonde weight

Authors: We agree with the reviewer's grammatical suggestion. Line 315: The sentence has been revised as suggested: "The parachute area should be tailored to match the radiosonde weight."

25) RC1: 344 "black dots represent receive radiosonde data stations of ADDRS" - "black dots represent ADDRS receiving stations"

Authors: We agree with the reviewer's grammatical suggestion. Line 332: The text has been changed to "black dots represent ADDRS receiving stations".

26) RC1: 354 "launches,of" - "launches, of"

Authors: We agree with the reviewer's grammatical suggestion. There is a missing space between the comma and the "of". Line 342: "launches,of" has been corrected to "launches, of".

27) RC1: Figure 6. The caption says "(a) drifting height; (b) descent height" but there is no (a) and (b); should just say"drift height"? The bar heights show percentage occurrence. I was surprised that the total bars are higher than both daytime and nighttime. On reflection the percentages may be calculated for all flights, but I think it *would be better if "daytime" showed the percentages for daytime flights and similarly for "nighttime".*

Authors: Figure 6: The caption has been corrected Line 353: “Figure 6. The drifting height of sounding-forecasting interactive network experiment (2021)”. The explanation of the percentage calculation has been clarified in the redrawn Figure 6.

28) RC1: 377 "verification FY-3D" - "verification of FY-3D"

Authors: We thank the reviewer for the careful correction. Following the suggestion, the phrase "verification FY-3D" in the original manuscript has been revised. To align with standard academic phrasing, we have adopted the more concise formulation "verification of FY-3D " in the revised text (Line 364).

29) RC1: 387-388 "Table 5 ... ascent phase compared with descent phase"

Authors: Rewritten this sentence. Lines 374-375: "Table 5 demonstrates good consistency between the ascent and descent phases for temperature, u-wind, and v-wind (Yao et al., 2026)".

30) RC1: 404-405 "And (Ingleby et al., 2022) noted that ECMWF's operational system excludes descent temperatures above 150hPa during assimilation due to these biases." [The biases have not been described.] From the author response response "We agree with the reviewer that a warm bias is evident in descent temperatures, particularly at higher altitudes, and that this bias is closely linked to descent rate. Ingleby et al. (2022) systematically investigated this issue ..." The warm bias issue should be mentioned in this section of the main text. It would be very useful to know typical and maximum descent rates of ADDRS at the start of the descent phase.

Authors: Thank you for highlighting this point regarding the warm bias in descent temperatures. We agree and have incorporated a discussion of this issue into the revised manuscript (Lines 390-393). As noted, a significant warm bias is evident in the descent temperature data, particularly at higher altitudes. This bias is closely linked to the initial descent speed following balloon burst, which can frequently exceed 50 m/s (Ingleby et al., 2022). Due to the biases introduced by such rapid initial descent, operational centers like ECMWF exclude descent temperatures above 150 hPa from assimilation. In line with this established practice, our data analysis for the comparisons presented in this study (including Table 5) applied a similar quality control filter. Data with excessively high initial descent rates were excluded from the comparison with ERA5. This step contributes to the better agreement seen in the results. We have added a note in the main text to briefly mention this quality control procedure.

31) RC1: 400-402 "We also note that the discrepancies between the measured wind and temperature data during the drift phase and the ERA5 reanalysis data are significantly larger, a phenomenon consistent with most radiosonde data comparisons at high altitudes (typically above 300hPa) against ERA5 (Liu, B et al., 2021)." See general comment 1 and issues about representation error and the question of whether a single latitude/longitude was used for ERA5 comparison with the drift data. B Liu et al, 2021 was not accepted and it shows winds but not temperatures so is not an ideal reference. Other sources would be better eg Fig 7 of Pauley and Ingleby (2022) (this shows results over Europe) or Ingleby 2017, ECMWF Tech Memo 807, Figure 3.11 shows O-B results for China, with a modest local maximum in wind differences at 300-250 hPa.

Authors: The issue of representation error in comparing drift-phase data with ERA5 has been addressed in the revised discussion per Comment 1. Lines 385-389: The description of the "The wind data from the drift phase were validated through dedicated experiments involving accelerometers, applying filtering principles consistent with Marlton et al. (2015). However, we note that the discrepancies in the stratospheric drift phase (both wind and temperature) are larger. This is consistent with findings from other studies comparing high-resolution radiosonde data with reanalyses (Pauley and Ingleby, 2022; Ingleby, 2017). such differences are often attributed to representation errors arising from the inherent resolution mismatches. "

32) RC2: l408: Please specify in the table caption how the difference was calculated. Was it obs-ERA5 or ERA5-obs. And Table 5: Do you mean Above Tropopause and Below Tropopause? Below Troposphere makes no sense, since that would be at the surface or below!

Authors: We thank the reviewer for the careful correction. Line 394: We have specified in the table caption that the difference is calculated as (Observation - ERA5, for short O-A). We apologize for the error and have corrected "Above/Below Troposphere" to "Above/Below Tropopause" in Table 5 and its corresponding description.

33) RC2: l411: potential to capture (not potential for capture)

Authors: We agree with the reviewer's grammatical suggestion. Line 397: The text has been corrected to: "potential to capture".

34) RC2: l417: in tracking the occurrence

Authors: We agree with the reviewer's grammatical suggestion. Line 403: The text has been corrected to: "in tracking the occurrence".

35) RC2: l434: suggests intensive upward motion

Authors: We agree with the reviewer's grammatical suggestion. Line 420: The text has been corrected to: "suggests intensive upward motion".

36) RC2: l445: Unlike GTS12 radiosondes, the ADDRS radiosondes provide measurement data of both ascent and descent phase for numerical weather prediction (NWP), achieving ...

Authors: We agree with the reviewer's grammatical suggestion. Lines 431-432: The sentence has been revised as suggested: "Unlike GTS12 radiosondes, the ADDRS radiosondes provide measurement data of both ascent and descent phase for numerical weather prediction (NWP), achieving …"

37) RC2: l491: Targeted observations have sometimes been a frontier field in atmospheric science.

Authors: We agree with the reviewer's grammatical suggestion. Line 484: The sentence has been revised as suggested: "Targeted observations have sometimes been a frontier field in atmospheric science."

38) RC1: 550-551 "ADDRS discharge radiosonde observations station" - "ADDRS launch station"?

Authors: We thank the reviewer for the helpful suggestion. Line 543: The phrase "ADDRS discharge radiosonde observations station" has been revised to the more standard and concise term "ADDRS launch station" in the manuscript.

39) RC1:551 "discharge time" - "launch time"? (or time at which descent should start?)

Authors: We thank the reviewer for the suggestion. The term "discharge time" has been revised to the more conventional "launch and subsequent descent phases time" in the manuscript (Line 544).

40) RC1: 560-561 "expected that 'SAOLA' would land" - "expected that 'SAOLA' would make landfall"

Authors: We thank the reviewer for the precise correction. The phrase "expected that 'SAOLA' would land" has been revised to the meteorological standard term "expected that 'SAOLA' would make landfall" in the manuscript (Line 554).

41) RC2:l591: This sentence is unclear. Do you mean: ADDRS represents a possible next-generation approach for upper air sounding, adding substantial flexibility compared to currently operational sounding systems. ?

Authors: We thank the reviewer for the helpful suggestion to improve clarity. The sentence at Line 584-585 has been revised as suggested and now reads: "ADDRS represents a possible next-generation approach for upper-air sounding, adding substantial flexibility compared to currently operational sounding systems."

42) RC1: 601-603 "We are confident that statistically significant improvements in precipitation forecast skills will be achieved as the data records lengthen and the number of case studies, particularly for extreme precipitation events, increases in the future."

I think this sentence should be deleted, it makes claims that will never be put to the test (because the old

radiosondes will be withdrawn soon), and when I run OSEs without radiosonde data the main impact is on upper level winds and low level temperatures.

Authors: We agree with the reviewer's assessment. The sentence at Line 595 has been removed from the manuscript. We appreciate the reviewer's constructive feedback on strengthening the conclusions.

43) RC2:l607: what do you mean with "continuous deepening of the measurement data"? Please rephrase or omit.

Authors: We agree with the reviewer's assessment. The sentence at Line 597 has been removed from the manuscript. We appreciate the reviewer's constructive feedback on strengthening the conclusions.

44) RC2:l610: to the editor

45) RC1:610 'theEditor' - 'the editor'

Authors: We thank the reviewer for pointing out this typographical error. The text at Line 614 has been corrected to: "to the editor".

46) RC1: 613 'platform((' - 'platform ('

Authors: We thank the reviewer for pointing out this typographical error. The extra parenthesis in "platform((" has been corrected to "platform (" in the revised manuscript (Line 599).

47) RC1: 614 'December this year' 'December 2025' presumably

Authors: We thank the reviewer for the clarification. The phrase "December this year" has been updated to the specific and unambiguous date "December 2025" in the revised manuscript (Line 601).

48) RC2:l612ff: Contrary to the statement of the authors This web link still does not work (on 22 Jan 2026), so the data must be considered unavailable.

49) RC1:613 https://www.r7tec.com/html/report/20040875-1.htm This (data availability) link exists, but doesn't indicate in English how to access the data or register.

Authors: Thank you to both reviewers for your diligence in checking the data availability link and for your constructive feedback. We sincerely apologize for the persistent access issues and the initial lack of clarity in the access instructions, which have now been fully addressed.

Link Correction and Data Update: The link in the Data Availability Statement has been verified and corrected to a fully functional one. More importantly, in response to the need for a more user-friendly format, we have updated the data provided at this link. Previously, it contained only 12 samples in PDF format (6 stations, 2 times per day, showing ascent-drift-descent profiles). We have now converted the data to the more accessible and widely used NetCDF (.nc) format. Enhanced Data Description and Usability: To facilitate easier use, the header of each NetCDF file now clearly labels the start time, end time, and duration of each of the three flight phases (ascent, drift, and descent). This structured metadata allows users to immediately parse and utilize the time-series data for each segment of the flight.

Current Data Access Pathway: We acknowledge that establishing a fully open, automated registration and download portal is a work in progress. In the interim, to ensure responsible data sharing and support collaborative science, we have clarified the access procedure. Researchers interested in the ADDRS dataset for scientific use are invited to contact the ADDRS research team directly via gqyaoc@cma.gov.cn to register. Data sharing will be facilitated through joint research initiatives, which we believe is the most effective way to expand data utilization and foster scientific collaboration at this stage. This point has been explicitly added to the revised Data Availability Statement. We appreciate your feedback, which has directly led to a more robust, usable, and clearly described data sharing mechanism for our manuscript.

50) RC1: There are various references in the wrong order Liu references should be in order of initials. Lau should come before Liu. 759-762 Wang, J. H. et al 2015 and WMO references are not in alphabetical order

Authors: We have carefully corrected the entire reference list (Lines 619-824) to ensure strict alphabetical ordering by the first author's surname, as required by the journal. This resolves the specific instances you noted (e.g., Lau before Liu, Wang and WMO in correct order). Furthermore, we have conducted a thorough secondary verification to ensure full compliance with the Atmospheric Measurement Techniques submission guidelines. Specifically: For multiple entries by the same first author, the order now follows: single-author papers, followed by two-author papers, followed by multi-author (et al.) papers. All journal names have been verified for correct standard abbreviations. DOI identifiers are included for all applicable entries. All in-text citations have been cross-checked for consistency and completeness against the final list. We believe the reference list is now fully formatted according to the journal's specifications. Thank you again for bringing this important issue to our attention.