

Dear Editor,

We sincerely thank you for your positive assessment and for giving us the opportunity to further refine our manuscript. We appreciate your constructive comments, which have helped us improve the clarity, statistical rigor, and overall presentation of our work.

We have addressed all the points raised in your decision letter and revised the manuscript accordingly. Below is our point-by-point response detailing the specific modifications made.

Point-by-Point Responses

1) Editor's Comment: Please address all the points by the reviewer. In particular, I would like to stress again that you should tone down the importance of the year 2003. It just happens to be the midpoint of our time series. I don't see that something very particular happened back then. And so be careful with words like 'shift' and 'threshold' in this context. Maybe better to call it 'early 2000s transition'? Please check throughout the entire manuscript for consistent wording.

Response:

We fully agree with this important remark. We acknowledge that 2003 simply corresponds to the chronological midpoint of our 1983-2024 baseline (21 years on either side), meaning its intersection with the baseline mean is a mathematical consequence of the monotonic linear Sen's slope rather than an abrupt physical tipping point.

We have conducted a thorough audit across the entire manuscript to tone down the narrative regarding 2003:

- We have systematically removed terms like "**climatological threshold**", "**structural regime shift**", and "**tipping point**" when referring to 2003.
- We have adopted the suggested terminology, reframing the long-term evolution as a progressive "**early 2000s transition**" toward a moister background state.
- We explicitly mention in Section 3.1 that 2003 represents the mathematical midpoint of the study window where the trend line intersects the baseline mean, emphasizing the multi-decadal nature of the humidification process rather than a single-year boundary.

2) Editor's Comment:

Abstract, L57: Omit the part after 'creating'

Response: Done. We have removed the clause following "creating" in Line 57 of the Abstract to make the statement more concise and direct. The revised sentence now reads:

Furthermore, negative ω anomalies throughout the troposphere indicate a northward extension of the monsoon's upward branch.

3) Editor's Comment: Abstract L58: Why 'strict'? You can omit that, too.

Response: Done. The word "strict" has been omitted from Line 58 of the Abstract as requested.

4) Editor's Comment: Fig. 1 and elsewhere: It is 'panel A', not caption!

Response: We apologize for this incorrect terminology. We have replaced all instances of "caption A/B" with "Panel A/B" in Figure 1 and ensured consistent terminology across all figure captions and in-text cross-references.

5) Editor's Comment: L318: You do not need so many digits for g here.

Response: Corrected. We have simplified the value of the gravitational acceleration constant g to standard precision $g = 9.81m \cdot s^{-2}$ in Line 318.

6) Editor's Comment: Fig. 4 and others: Has some very small font. Please increase to enhance legibility.

Response: We have updated Figure 4 as well as Figures 1, 3, 5, and 6 to significantly enlarge all text elements, including axis labels, tick marks, legends, and colorbar annotations.

7) Editor's Comment: P 17: Long text passage without any paragraphs.

Response: Done. We have broken down the long text passage on page 17 into three (03) well-structured paragraphs to enhance readability and improve the logical narrative flow.

8) Editor's Comment: L585: Old subheading 3.2?

Response: Corrected. The leftover heading "3.2. Atmospheric drivers" at Line 585 have been completely removed.

9) Editor's Comment: L917: Do you mean 'record-breaking'?

Response: Yes, exactly. We have updated Line 917 to use the correct terminology: "record-breaking".

10) Editor's Comment: L418: Should it be 'Fig.'?

Response: Done. We have corrected the reference at Line 418 to "**Fig.**"

We hope that these revisions satisfactorily address all your requests and that the updated manuscript is now suitable for publication.

Sincerely,

The Authors

Answer to reviewer comments

I would like to thank the authors for taking the time to respond to all my comments. This new version of the manuscript meets all the criteria for publication and is far better than the previous one. I really appreciate the consistency of your study, especially regarding the 'multi-scale analysis' mentioned in the previous version, and the effort you put into the Methods section. The level of detail in the analysis and the quality of the graphics make this a valuable contribution to the field, particularly given the lack of literature on the Chad region and the fact that these extreme events still cause significant damage. I've noted your remark about the accessibility of in situ data. I also had concerns about it and I completely understand why you can't use it. Moreover, the commentary about satellite products is very convincing. Finally, I totally understand that you do not want to extend the scope of this study to the daily and sub-monthly environmental conditions. I really enjoyed your idea for a dedicated study of the 9-14 August period and I look forward to reading it. As far as I am concerned, some technical corrections need to be made (you can find the list below), but no major or minor revisions have been identified. I have just two remarks about your study.

Answer: We would like to sincerely thank the reviewer for their positive evaluation, warm encouraging comments, and constructive feedback throughout the revision process. We are delighted to hear that the revisions and additional details, particularly in the Methods section and graphics, have enhanced the clarity and overall quality of our manuscript.

We also greatly appreciate the reviewer's understanding regarding the data constraints (in situ and satellite products) and the defined scope of our study. Their feedback has undoubtedly helped strengthen this contribution to the understanding of extreme weather events in the Chad region.

Please find below our point-by-point responses to the two final remarks and technical corrections.

Firstly, you still describe the year 2003 as a “climatological transition threshold”. In my opinion, changing the climatological period (for example, by introducing a 5-year lag) would cause the long-term linear Sen's slope to intersect the baseline average in a different year (5 years earlier for the example). The formulation in the text is clearer and less open to misinterpretation than in the previous version of the manuscript. I just want you to be aware that the result depends on the climatological period.

Answer:

We sincerely thank the reviewer for this insightful comment and for confirming that our wording has become clearer. We fully agree with your statistical reasoning: given that the intersection of a long-term linear trend line with the baseline average depends strictly on the chosen time window,

defining a specific year as an absolute physical or structural threshold is an approach that varies depending on the period under consideration.

We appreciate that the reviewer noted that our current text is clearer and less prone to misinterpretation. To make the wording even more precise and completely eliminate any ambiguity regarding period dependence, we have made a slight modification to Section 3.1. Specifically, we have replaced the phrase “climatological transition threshold” with “chronological midpoint of the transition.”

This subtle adjustment preserves the narrative of a continuous shift, spanning several decades, toward wetter conditions and a reduced frequency of severe drought years after the 2000s, while ensuring that the year 2003 is explicitly understood as the geometric midpoint of the 1983–2024 series rather than as an intrinsic physical boundary independent of the time period.

The section 3.4 (formerly section 3.2) is clearer, but its organisation does not align with the response provided to reviewers on pages 15–16. Please check your version of the manuscript.

Answer: We would like to thank the reviewer for pointing out this discrepancy and apologize for the confusion caused in our previous response document.

After reviewing the previous response material, we realized there was an error in cross-referencing sections and figures on pages 15 - 16 of our document:

1. The thermodynamic analysis involving Moist Static Energy (MSE) and equivalent potential temperature (θ_e) which was referenced on pages 15–16 of the previous response corresponds in fact to Section 3.7 (and Figure 9) of the revised manuscript, rather than Section 3.4 (and Figure 6).
2. Section 3.4 specifically covers the spatial distribution of 850 hPa specific humidity anomalies and horizontal moisture flux fields, whereas Section 3.7 explicitly presents the low-level MSE and θ_e energetic framework.

We have thoroughly cross-checked the entire manuscript to ensure complete alignment between the section headers, text descriptions, figure callouts (including Figure 9 for Section 3.7), and the narrative presented across all review materials.

Technical corrections :

- L204-208: Thank you for taking my advice about the wind divergence into account. Unless you wish to retain it, this commentary is unnecessary. You can simply add the wind divergence to the sequence of meteorological variables (L204) that you extracted from ERA5."

Answer: We thank the reviewer for this constructive suggestion. We agree that the detailed commentary regarding the direct extraction of wind divergence from the native ECMWF outputs is no longer necessary.

Following your recommendation, we have removed the explanatory commentary (former lines 204–208) and directly included horizontal wind divergence (d) in the list of retrieved ERA5 atmospheric variables.

- L282: Be careful of redundant notation (T is defined here as both the return period and the temperature at L349).

Answer: We thank the reviewer for catching this notation conflict. To avoid any ambiguity, we have redefined the return period notation as “Tr” throughout the text, while reserving “T” strictly for atmospheric temperature.

- L318-320: There is no need to define q, u and v again.

Answer: Done. We have removed the redundant definitions of specific humidity (q) and horizontal wind components (u, v) in L318-320, as they were already introduced.

- L352: The gravitational acceleration g is already defined in L318, as is the specific humidity.

Answer: Corrected. We have removed the duplicate definitions of the gravitational acceleration g and specific humidity q in L352.

- L477-481: You use TAMSAT as a reference for this Figure 4, as you mentioned it in the text. Could you also mention this in the figure caption?

Answer: We have updated the caption of Figure 4 to explicitly specify that the precipitation fields shown are derived from the TAMSAT satellite dataset. The figure caption in the revised manuscript is:

*“Figure 4: Spatial distribution, magnitude, and statistical significance of August precipitation over Northern Chad **derived from the TAMSAT product**. Panels display (a) the multi-decadal baseline climatology (1983-2023), (b) absolute monthly rainfall accumulations for August 2024, and (c) the corresponding standardized anomalies (Z-score). Stippling in panel (c) denotes statistically significant anomalies ($p \leq 0.05$) derived from a grid-point-wise Monte Carlo simulation.”*

- L503-508: Can you indicate in the caption or in the Table that the Observed Value (August 2024) is an average on the study domain?

Answer: Done. We have explicitly specified in both the title of Table 1 that all reported August 2024 observed values represent spatial averages computed over the Northern Chad study domain. The caption in the revised text manuscript is:

*“Table 1: Parametric Return Periods and Non-Parametric Thermodynamic Percentile Ranks for the August 2024 Extreme Event **based on spatial averages** over the Northern Chad study domain (16°N-24°N, 13°E-25°E). Rainfall metrics are based on a Gamma distribution fitted via Maximum Likelihood Estimation (MLE) over the 1983–2024 baseline. Specific humidity (q) and Total Column Water Vapor (TCWV) metrics represent empirical ranks and percentile ranks calculated using the Weibull formula over the same climatological period ($N = 42$ years).”*

- L585: You forgot to suppress “3.2. Atmospheric drivers”

Answer: Thank you for noticing this leftover header. The redundant section title “3.2. Atmospheric drivers” has been completely removed.

- L702: “pink shading” instead of green

Answer: Corrected. We have updated the text in L702 to correctly refer to "pink shading".

- Section 3.7 and Figure 9: Contrary to your response to the reviewers, you forgot to mention the MSE and θ_e levels in both the text and the caption.

Answer: We apologize for this oversight in the previous revision. We have now explicitly stated both in the body text of Section 3.7 and in the caption of Figure 9 that the Moist Static Energy (MSE) and equivalent potential temperature θ_e fields are evaluated at the 850 hPa pressure level.

- L863: "(Fig. 10)" instead of Fig. 8

Answer: Corrected. The cross-reference in L863 has been updated to "(Fig. 10)" to ensure accurate numbering with the revised figure sequence.

- L879 and 884: "Table 2" instead of Table 1

Answer: Corrected. The table callouts at lines 879 and 884 have been updated to "Table 2" to match the actual table numbering in the manuscript.