

Answering the questions posed to reviewers:

1. *Does the paper address relevant scientific questions within the scope of WCD?*

Yes.

2. *Does the paper present novel concepts, ideas, tools, or data?*

Yes.

3. *Are substantial conclusions reached?*

Conclusions are reached. Locations with atmospheric deserts are associated with anomalously high near-surface temperatures, higher prevalence of lightning, and more dust than the same locations not experiencing an atmospheric desert.

4. *Are the scientific methods and assumptions valid and clearly outlined?*

The methods and assumptions appear to be valid.

5. *Are the results sufficient to support the interpretations and conclusions?*

Yes.

6. *Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?*

Other than a few technical points (e.g., Appendix A1), I felt that I could mostly understand and follow the methods.

7. *Do the authors give proper credit to related work and clearly indicate their own new/original contribution?*

The authors do credit previous work. Well done. However, the authors could better explain their new and original contribution. See further comments below.

8. *Does the title clearly reflect the contents of the paper?*

“Extreme weather events” is here used for “positive temperature anomalies”, “thunderstorms”, and “dust”. “Extreme weather events” is vague. This could be more precise. Also, the location is not specified. Therefore, the title could be shorter and more precise with a revision such as, “Occurrence of atmospheric deserts with positive temperature anomalies, thunderstorms, and dust in Europe”.

9. *Does the abstract provide a concise and complete summary?*

The abstract is concise.

The abstract is incomplete. Only the last paragraph (of four) discusses the results of the study, with only one quantitative piece of information mentioned. More results should be presented in the abstract, with more quantitative information.

The abstract does not say why this study is important. It goes from "Atmospheric deserts are frequently advected over Europe...." to "We therefore investigate their co-occurrence...." This transition omits the research question(s) that the authors are attempting to answer.

*10. Is the overall presentation well structured and clear?*

The presentation is well structured and clear, perhaps too well structured, with four levels of organization in section 5. I suggest revisions that would reduce the number of subsubsubsections needed. See further comments below.

*11. Is the language fluent and precise?*

Yes, but the manuscript seems to require more proofreading, having noted numerous misuses of words, improper punctuation, and incorrect scientific notation. More care should be taken before submission.

*12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?*

Mostly.

Temperature should be abbreviated  $T$ , not  $t$ . Variables should be italicized.

The definition of conditional instability provided by the authors is incorrect.

*13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?*

I have suggested breaking up section 5 into three separate sections. Some of the appendices should be integrated into the text.

*14. Are the number and quality of references appropriate?*

Yes.

*15. Is the amount and quality of supplementary material appropriate?*

Not applicable.

## General Comments

1. The introduction would benefit from clearer structure and organization. Consider the topics of the sentences.

- 1 – Definition of atmospheric deserts
- 2 – Transport and modification of atmospheric deserts
- 3 – Atmospheric deserts as a generalization of EMLs
- 4 – A detection method that enables this study
- 5 – Occurrence of atmospheric deserts in Europe
- 6 – Influence of EMLs on thunderstorms and heatwaves (23 citations)
- 7 – A June 2022 AD case associated with thunderstorms and high temperatures
- 8 – The question of whether ADs exhibit behavior similar to EMLs and co-occur with positive temperature anomalies (PTAs), and whether thunderstorm formation is favored in specific regions of ADs
- 9 – The occurrence of dust within ADs

This outline highlights several issues with the introduction.

First, the discussion assumes familiarity with the authors' prior work on atmospheric deserts. Providing additional context on what has been done previously would help orient readers who are new to this framework.

Second, the manuscript does not clearly explain why the AD paradigm provides added value relative to existing paradigms. If ADs are specific manifestations of the more general EML concept, it would be useful to clarify why a new conceptual model is needed and what additional insights it enables that could not be obtained using an EML-based approach.

Third, the paragraph comprising sentences 5–9 moves between multiple topics, including AD occurrence, EMLs, a specific AD case study, and broader research questions. Reorganizing this discussion to follow a more linear progression would improve clarity.

Fourth, the specific problem that this paper is intended to address is not stated explicitly. Making this clearer would help frame the study and its objectives.

2. By the time the reader reaches the conclusion section, the main results are presented: Locations with atmospheric deserts are associated with anomalously high near-surface temperatures, a higher prevalence of lightning, and increased dust relative to times without atmospheric deserts. While these results are original, the manuscript would benefit from a clearer discussion of their implications. In particular, it would be helpful to explain how these findings advance understanding of EML-related processes and convection.

3. Lines 35–36 state the goal of the manuscript: "In this work we want to address the question whether ADs show a similar behaviour as EMLs and co-occur with positive temperature anomalies (PTAs), and whether thunderstorm formation is favoured in specific regions of the ADs." As written, this goal is not fully addressed. Although the manuscript examines the frequency of ADs in Europe, it does not assess whether this behavior is similar to that of EMLs, as no direct comparison is performed for Europe, North

America, or globally. Revising this statement so that it aligns more closely with the analyses actually performed would improve consistency.

4. The presentation of the results is highly analytical in tone. Additional interpretation linking the statistical results to physical understanding of EMLs and convective processes would strengthen the manuscript.

5. The manuscript often assumes a level of background knowledge comparable to that of the authors. As a result, it can read as communication between specialists rather than as a presentation aimed at a broader readership. Providing more explanation of the results and their significance would help readers encountering these ideas for the first time.

#### Other Comments

6. Should the abstract be one paragraph?

7. Most of the abstract describes the method. Only the last paragraph (five sentences) contains results, and those results are not particularly quantitative (for example, lines 15–18). Expanding the results portion of the abstract would improve balance.

8. Line 23: Is “advected” the most appropriate word here? Advection is defined as the transport of an atmospheric property by the velocity field. <https://glossary.ametsoc.org/wiki/advection/> Referring to an atmospheric desert (an object) as advected may not be precise. Consider revising this wording consistently throughout the manuscript.

9. Line 27: “as it does not require recognisable features in the vertical profiles of the target regions.” This phrase is unclear and could be clarified.

10. Lines 28, 29: The phrase “have been shown to” can be deleted without loss of meaning.

11. Sentence starting at line 29: While the list of 23 citations indicates that EMLs are widely recognized as being associated with thunderstorms and heat waves, it does not constitute a particularly discerning assessment or critique of the literature.

12. The manuscript transitions from “heat waves” (e.g., line 29) to positive temperature anomalies (line 36). Although this may appear subtle, it is an important distinction. Heat waves typically imply longevity and extreme magnitude, whereas PTAs are instantaneous and may represent relatively small departures from the mean. It would be helpful to justify whether PTA is the most appropriate term for standardized anomalies of two and four standard deviations.

13. Are acronyms such as AD, BL, BLH, and PTA necessary, or could some be removed to improve readability? Spelling out most, if not all, acronyms makes for less effort on the readers.

14. Stick with more common notation. Temperature at 2 m should be written as  $T_{sfc}$  or  $T_{2m}$ , not  $t_{2m}$ .  $duaod_{550}$  should be  $AOD_{500nm}$ .

15. Line 47: Delete “found to be”.

16. Line 49: The meaning of “emerge” is unclear in this context. Clarification is needed.
17. Lines 49–51: The description of these air streams is difficult to follow. Additional information about their characteristics and trajectories would improve clarity. Alternatively, if these details are not essential, the text could be shortened or removed.
18. Line 52: The first sentence is incomplete.
19. Line 59, and elsewhere: Meteorological processes should be described using precise terminology. For example, convection *initiates* rather than *erupts*.
20. Line 66: “edge” is misspelled.
21. Line 69: The phrases “similar behavior” and “more general case” are unclear, particularly given that the paragraph discusses multiple mechanisms of CIN weakening. Clarification is needed.
22. Taking the log of OR produces a symmetric field around zero, but loses the easy interpretability of the OR. Reconsider whether presenting the results as OR would be preferable.
23. Line 99: The term “binary” is unclear in this context. Please clarify or remove it.
24. Line 100: The basis for classifying a single flash as an “erroneous outlier” is unclear. A single flash could represent a valid event; further justification is needed.
25. Line 117: Strictly speaking, “grid interval” or “grid spacing” is more appropriate than “resolution”.  
  
Grasso, L. D., 2000: The Differentiation between Grid Spacing and Resolution and Their Application to Numerical Modeling. *Bull. Amer. Meteor. Soc.*, **81**, 579–586, [https://doi.org/10.1175/1520-0477\(2000\)081<0579:CAA>2.3.CO;2](https://doi.org/10.1175/1520-0477(2000)081<0579:CAA>2.3.CO;2).
26. Line 124: Change “Fore” to “For”.
27. Lines 128–130: The meaning of “small holes and speckle” is unclear. Consider rephrasing or explaining these terms.
28. Line 132: Delete “It is found that”.
29. Line 133: Insert “thick” after “(3 levels)”?
30. Lines 156–158: The definition of cap changes relative to earlier usage. This change and its reason should be explained in more depth in the text.
31. Line 160: The use of the word “receptively” is unclear in this context.
32. Line 172: Delete “It should be noted that”.
33. Line 188: Clarify why “conditional” is capitalized and enclosed in parentheses.

34. Lines 188–189: This appears to be two sentences spliced together with a comma. Revision is needed.
35. Line 198: Should “AD” be “ADs”?
36. Line 200: Delete the comma after “event”.
37. If temperature is to be abbreviated, then use a capital and italicized *T* to be consistent with meteorological convention. Lower-case *t* denotes time.
38. The notation for anomaly should use a straight apostrophe (’), not a single quotation mark (‘).
39. Line 209: Capitalize “Bay”.
40. Lines 211–212: “This pattern is also reflected in the mean and median of  $t_2m'$  during AD and non-AD periods” requires a figure citation. Please indicate the relevant figure.
41. The figures in Appendices B and C are frequently referenced and appear integral to understanding the paper. Including them in the main text and explaining them more fully would improve readability.
42. The paragraph beginning at line 215 cites Fig. B2, which is necessary for interpreting Fig. 2. This further supports integrating these figures into the main text.
43. The relatively small difference between median temperatures during AD and non-AD periods (Fig. B1) is somewhat unexpected. A similar issue arises in lines 236–238 concerning the British Isles (only 20% of AD cases occur with PTAs). Further discussion of the implications of these findings would be helpful.
44. Figure 1b. The gray lines and contour labels are difficult to see.
45. Line 225: The phrase “there positive” is unclear and should be corrected.
46. The separation between the presentation of results (section 5.1.1) and their discussion (section 5.1.2) makes the text harder to follow. Consider discussing the results of Fig. 1 immediately after it is presented, as well as the other figures in the other subsections of section 5.
47. Line 231: The rationale for omitting these two summers should be explained.
48. Line 235–236: What figure is being referenced here? Remember to cite figures for all sentences that refer to a figure.
49. Line 238: Studies don’t “observe”. People observe. Studies “report” or “show”.
50. Line 238: Temperature is a metric. It is either high or low. Water or air is an object that can be warm/cold/hot. “High (or positive) temperature anomalies” is the appropriate phrasing.

51. Line 245: The term “elevated” is ambiguous when referring to boundary-layer air over high terrain. Greater care is needed to distinguish between height above the surface and higher thermodynamic values. See also lines 249, 364, and elsewhere.

52. Line 246: The phrase “making penetration possible” is unclear and disrupts the flow. Clarification or revision is recommended.

53. Line 248: The phrase “the terrain is also elevated” is ambiguous and should be clarified.

54. Lines 254, 271, and elsewhere: “However” should not be used as a conjunction to join two independent clauses. <https://www.cdc.gov/nceh/clearwriting/writing-tips/2025/however-does-not-equal-but.html>

55. The three levels of subsections (e.g., 5.1.2) plus another level of subsections (e.g., “Capping inversion”, “Preferential warming...”) reduce readability. Consider making section 5.1 into section 5, section 5.2 into section 6, and section 5.3 into section 7.

56. Line 261: The term “warming” implies a temporal increase. Consider whether “anomalously high temperature” would be more precise.

57. Line 261: Why “preferential”? Preferential to what? Consider removing it if it does not add substantive meaning.

58. Lines 321–322: “A layer is conditionally unstable when the potential temperature gradient  $\partial\theta/\partial z = (\theta_{BLH+2km} - \theta_{BLH}) / 2 \text{ km}$  is less than  $3.5 \text{ K km}^{-1}$ .” Conditional instability is when the saturated equivalent potential temperature decreases with height. Please explain the rationale for using potential temperature and for the threshold of  $3.5 \text{ K km}^{-1}$ . Provide citations to original source material.

59. Lines 328–329: “a conditionally unstable layer provided by the AD with modest CIN values underneath makes it possible for thunderstorms to occur even in the centre of an AD”. This statement linking a conditionally unstable layer and modest CIN to thunderstorm occurrence appears primarily based on parcel theory. Provide the meaning of this statement.

60. Lines 331–332: “These results can be expected also approximately hold when taken over the whole day instead of daytime only.” This claim is not supported by evidence presented here. Please clarify.

61. Line 332: It is unclear what “this” refers to or why it is considered a new result.

62. Lines 340–341: “describe describe”

63. Line 361: Delete the comma after “event”. See also lines 486 and 495.

64. Line 391: The reason for placing “(and Barkan et al., 2005)” in parentheses is unclear.

65. Line 398: AARs are not defined at the point where they are introduced.

66. Line 408: Do you need both Summary and Conclusions in the title? Is one sufficient?

67. Lines 416–417: “we therefore addressed the co-occurrence of positive temperature anomalies, lightning, and dust events with ADs”: As written, this is unclear. “Co-occurrence suggests all three and ADs are simultaneously present. The word “occurrence” would make more sense.

68. Line 420: “the trapping of heat under a cap”: “Heat” is not an object that can be trapped, a common misconception in physics. Reconsider different wording for more scientific precision.

69. Lines 419, 421, 422, and elsewhere: “increased” or “enhanced” should be specified relative to a reference state or replaced with “higher”.

70. Appendix A1 is difficult to follow. Additional explanation may improve accessibility for non-specialists.

71. Figure caption A1: What is “9a-c)”?

72. Line 487: “the gradient of the potential temperature over those 500 m is greater than  $10 \text{ K km}^{-1}$ ”. This requires justification and a citation. There should be a space between the units K and km.

73. Line 495: Should “were” be “where”?

74. In various figures, values of  $\ln(\text{OR})$  are plotted only for very large values ( $> 10$  for Figs. 5 and C1;  $> 5$  for Figs. 1 and C2). In Figs. 2 and 3,  $\ln(\text{OR})$  is colored for all nonzero grid points. Is there a reason why  $\ln(\text{OR})$  shouldn’t be plotted for all nonzero  $\ln(\text{OR})$  as in Figs. 2 and 3? Doing so would show more structure in the fields and be consistent throughout the manuscript.