RESPONSE TO RC2

This is a clearly presented and succinct paper on an interesting topic. However, in my opinion there are some major issues that must be addressed before the paper is considered for publication. I am in full agreement with concerns already raised by the other reviewers, and I provide my own major and minor issues below. The key point (relevant to all my major issues – and raised by the other reviewers) – is that the virtues of the new humid-heat metric are not at all clear. This is very problematic because using relative humidity (RH) over an absolute measure of humidity (like the absolute or specific humidity, or the vapour pressure) is not the obvious choice from an impacts' perspective; it also challenges interpretation of 'dry' and 'moist' heat events. The lack of context regarding how the MELT index is an improvement on other work also does not help convince of the benefits provided by the new index.

Major issues

1. There is a misrepresentation of the extent to which previous work has engaged with this topic. For example, please see Matthews et al. (2022) and Ivanovitch et al. (2024). The former discusses the use of equivalent temperature (and the 'latent' temperature) as a physical quantity to characterise humid heat; the latter presents a novel new metric to communicate the extent to which humidity (and temperature) contribute to a specific level of humid heat (e.g., a given wet-bulb or equivalent temperature, noting that equivalent temperature is (MSE-gz)/Cp). How does the manuscript advance on such work (noting that the above are not empirical metrics/tailored for regional applications)?

   Response

   We thank the reviewer for the insightful comment. We acknowledge that the aforementioned studies have made significant advances in the field, particularly through multi-region analyses and the use of non-empirical metrics. To complement and further this progress, our proposed index is designed with the following advantages in mind:

   - **Ease of calculation** – It is simple to compute using readily available atmospheric variables.
   - **Accessibility** – It is applicable in data-sparse regions where observational data, such as wet-bulb temperature, may be unavailable. In such cases, reanalysis data can be used effectively.
   - **Computational efficiency** – The index is computationally inexpensive, making it suitable for large-scale or real-time applications.
   - **Flexibility** – It can be adapted to different climatological benchmarks, such as the 95th percentile thresholds across varying climate regimes.

   Our goal is not to replace existing methods, but to provide an additional, practical tool for identifying and analyzing heatwaves, particularly in regions with limited resources. We have made modifications in various parts of the manuscript to refine it succinctly and convey these points.

2. The MELT index might, at least in theory, miss extreme humid events due to the initial dependence on dry-bulb temperature to identify a heatwave. For example, Tmax

might not be that extreme yet, because of very high RH, the wet-bulb temperature could be.

Response

We thank the reviewer for the insightful comment. We acknowledge the reviewers' concerns; however, the literature has shown that RH has been used in the health sector and has been identified to correlate well with how people feel. Hence, although this might be a limitation, the index is still able to quantify heatwaves, although it might not be entirely applicable to heat stress

3. Despite the claims in the paper, I don't think you can compare/characterise 'humid' and 'dry' heatwaves using MELT. Under the authors' definition, a heatwave could be interpreted as dry (e.g., MELT<1 due to relatively low RH) – or at least drier than during a heatwave in another region -- even if the specific humidity was extreme due to very high dry-bulb temperature (and hence higher saturation specific humidity). The same issue is there if we compare heatwaves at a single site. To illustrate, imagine two heat waves (a and b) in the same place with identical specific humidity. If b had higher dry-bulb temperature than a, its MELT would be lower (because saturation specific humidity, and hence RH, would decline). Yet, from a human heat stress perspective, we would expect the cooling potential via sweating to be very similar between heatwaves a and b because that depends on specific/absolute (and not relative) humidity. There are arguments for using RH rather than an absolute measure of humidity; please elaborate if this remains the choice for the MELT index.

Response

We thank the reviewer for raising an important and nuanced point about the interpretation of MELT and its relationship with heatwave humidity characteristics.

We agree that MELT, by incorporating relative humidity rather than specific (absolute) humidity, can sometimes lead to counterintuitive characterizations of humid vs. dry heatwaves, particularly in the cases described by the reviewer. As noted, relative humidity decreases with rising temperature when specific humidity remains constant, and therefore, two heatwaves with identical specific humidity but different temperatures may indeed be assigned different MELT values. Our intention in using MELT is to adopt a physically-grounded index that incorporates both temperature and humidity to estimate how humid an atmosphere is at the point when a heatwave is occurring. However, we acknowledge that MELT's dependence on RH can obscure the role of specific humidity in some cases, especially in extremely hot environments where RH naturally declines at a constant specific humidity.

To address this:

- We have revised the manuscript to clarify that MELT does not provide a direct classification of 'dry' versus 'humid' heatwaves in terms of specific humidity, but rather reflects the moisture content of the atmosphere during a heatwave event. Since RH is related to saturation, and hence, higher RH values could be a proxy for classifying how humid it is.
- We have added a brief discussion weighing the merits of RH-based versus specific humidity-based indices.

- Also, our analysis of the specific humidity in the synoptic scale section aligns with the results evinced in using RH in terms of region of high moisture relative to regions of low moisture contents

We appreciate the reviewer's detailed scenario involving two heatwaves at a single location and have included a similar illustration in the revised manuscript to underscore this limitation.

Minor issues

Not all references appear correctly (i.e., only some are hyperlinked). Please check.

Response

We thank the reviewer for the comment. We have rectified this in the revised manuscript. In-text references are not hyperlinked, but every other reference is hyperlinked, just as it should be.

"If an event has a MELT index < 0.5 then, there is a relatively dryer [sic] heatwave with humidity lower than 50% of the climatological relative humidity"... Not quite, if I understand correctly – it'd be lower than the 47.5th % percentile? (Because the RH is 50 % of the 95th percentile?). Please correct or explain.

Response

We thank the reviewer for the comment. The reviewers' understanding is correct. This would mean the RH is 50% of whatever baseline climatology is used. That is, if the 90th percentile is used, then it would be 50% of that (45%). And this is a unique feature of the index which shows that if a different climate regime is used, the MELT index would charcterize heatwaves based on the climates regime and spatial representation of temperature and relative humidity.

Correct 'dryer' to 'drier' (I think it only occurs in one place (above), but please check).

Response

We thank the reviewer for the comment. We have made these changes in the manuscript.

References

Matthews, T., Byrne, M., Horton, R., Murphy, C., Pielke Sr, R., Raymond, C., Thorne, P. and Wilby, R.L., 2022. Latent heat must be visible in climate communications. *Wiley Interdisciplinary Reviews: Climate Change*, *13*(4), p.e779.

Ivanovich, C.C., Sobel, A.H., Horton, R.M. and Raymond, C., 2024. Stickiness: A new variable to characterize the temperature and humidity contributions toward humid heat. *Journal of the Atmospheric Sciences*, *81*(5), pp.819-837.