Linkages between atmospheric rivers and humid heat across the United States

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1. Summary

In this paper, Raymond et al, 2023 disentangle the relationship between Atmospheric Rivers (ARs) and humid heat occurrence over different regions in the US during the warm season (May to September). This approach considers peaks of wet-bulb temperature and computes the probability of occurring when detecting an AR at grid point and region level. This is also done for two other variables that typically represent ARs: precipitation and Integrated Water Vapour (IVT). Moreover, composites before and after the peak are calculated for key quantities related to humid-heat and ARs, allowing us to infer from the statistical relation which processes are key for these events.

2. General comment

I find this paper very interesting. It was quite easy to understand and enjoyable to read. The proposed method to assess such interaction between humid-heat and ARs focuses on the peak of humid-heat in order to examine the processes that cause humid-heat extremes rather than their maintenance. My main issue was with the "extent of the Data and methods". I was expecting a little bit more of explanation (e.g. selection of humid-heat days methodology, more detailed explanation of Relative Risk metric). There are some aspects that the authors should address before this paper can be published in NHESS. I will list them here, together with some minor/technical corrections.

3. Specific comment

L10-11: Consider rewriting the second sentence of the abstract to improve readability.

Section 2.2 (L64-69): What is the domain used for the AR-detection algorithm? The algorithm has geometric criteria, does it have a minimum AR extension threshold? If the domain where the detection algorithm is applied only considers the continental US, this domain can miss a significant amount of ARs due to its geometric criteria. Moreover, it can affect the results, especially in the Western US or areas close to the boundaries. If the AR detection domain used does not take this into account, consider applying the AR detection algorithm in a larger domain where the geometric criteria will not prevent detecting all the ARs. What one could do is to check if the number of detected ARs is similar to the AR Catalogue by Guan [1].

In **Section 2.3** it is explained how peak humid-heat days are selected. This method seems very restrictive, but is justified to explore the processes that lead to cause the humid-heat rather than maintaining it. Despite that, it would be good to know if the results are sensitive to the thresholds used for the "peak" framing or without the "peak" framing at all; consider including the sensitivity tests for this methodology if you have them.

L94-95: the Tw percentiles are computed over a 30-day-smoothed climatology. Why is this smoothing necessary to compute the 95^{th} percentile? Then, to define if a day is above the 95^{th} percentile from the smoothed climatology, you use the daily values without smoothing, which percentage of the total days fall above this threshold? Moreover, a 30-day smoothing seems

too strong, can you justify why 30 days and not 7 or 15 days, for example?

L121-122: What do the colours in brackets mean in the section a) of the caption for Figure 2? I thought the colours represented different US regions, it is confusing, consider removing them if they do not provide any useful information.

L122-123: The caption for Figure 2 section b) is not clear. Seems confusing when compared to what is written in section 2.4 (L132-135). Consider writing here what is shown in the Figure, but also make sure that it is consistent with section 2.4 (L132-135).

L131-132: Relative Risk metric is introduced and widely used in the paper, consider going more in-depth with the explanation of how it is calculated. And if possible, add a reference as well, this will facilitate interpretation of the results, especially for people not used to it. I would mention that "the particular sets of days" correspond to the peak humid-heat days, as this selection of days is always used in the calculation of relative risk. You could mention here that this is not only done for AR/humid-heat, but also for the precipitation threshold (1 mm) and IVT (Figure 4). Specify, which thresholds are used for these two variables, the precipitation threshold is described in Figure 4 caption, but for IVT has not been explained.

L149/L223: Relative likelihood is relative risk? Consider using one terminology or introduce this term in the methods section 2.4 (L131).

L149: Why the AR relative likelihood is within 2 days? In methods, Section 2.4 (L129) is stated to be within 1 day.

L167: change 500-mb to 500 hPa, as it is in the Methods.

L172: The results in the western regions can be sensitive to the AR detecting algorithm as mentioned in my comment for Section 2.2. Please, make sure your results are not limited by this issue.

L194: Which is the threshold of IVT used for the IVT/humid-heat relative risk? Consider writing this in the caption of the figure, but also in the Methods section.

L200: What is total IVT? Could you explain how it is computed? I have seen total IVT as the integration of an IVT vertical section across an AR to calculate the total amount of moisture an AR transports. I assume here this is not the case, please explain what it stands for.

L207-209: Here you state: "the decrease of dry-bulb temperature due to the shifting position of the ridge-trough system causes maximum Tw to occur on the first day of the pair", the Tw occur the first day of the pair, because the methodology on selecting peak Tw days forces to be this way. You could say that the day after the Tw peak (or the second day of the pair) the dry-bulb temperature decreases due to the shifting position of the ridge-trough, but the specific humidity (q) remains as high as the first day of the pair (or Tw peak day). I think you cannot imply causality in this case.

L221: Here, do the AR probabilities stand for the relative risk? I would refer to relative risk when corresponding, consider using the same therminology used in the Methods Section 2.4 to avoid confusion.

L221&223: First is used "hatched" to make reference to the tale colour information in subplots a,d,g and later is described as "contours". I believe it refers to the same thing, I would use the same wording to avoid confusion.

4. Technical correction

When referencing figures, the authors used 2 different forms, abbreviation as “Fig. ##” when added directly to the text or without abbreviation like “Figure ##” when added in brackets, I would be consistent and only use one form in the manuscript.

Figures 1 and 3 do not present any text in the colorbar (like “Relative risk of AR/humid-heat interaction”). I would be clear in the plots what the colour values stand for, not only in the caption of the Figures.

Figure 2: Both y-axis for subfigures a) and b) have the same label, but stand for two different relative risks (the second is controlled by z500) as described in the caption. Consider using different y-axis labels for clarity.

Figures 3 and 5: In the green labels are written “Pr[AR]” and in Figure 5 the blue labels are written “Pr[P]”. I understand they stand for relative risk, but I would rather rewrite them as RR[AR] and RR[P]. Pr[] can be confusing as it is used in other places with a different meaning.

Figure 4: Consider putting labels on top of each subplot for clarity, as it is done for Figure 5.

L221&223 (Figure 5 caption): The caption of subplots (b,e,h) and (c,f,i) are a bit confusing. The information in the caption does not always correspond to what is written in the legend at each subplot. Also, you write “as in (a,d,g)”, but instead of showing relative likelihood, you show percentiles. I would recommend making this caption description clearer not to confuse the reader.

5. References:

[1] GUAN, BIN, 2022, "[Data] Global Atmospheric Rivers Database, Version3", https://doi.org/10.25346/S6/YO15ON, UCLA Dataverse, V3