Reviewer 3

The authors thank Reviewer 3 for their time providing feedback which improved the manuscript.

This study claims to investigate trends in European hailstorm damage. The study presents two components. First, insurance data are used to show increasing insured losses owing to hail over recent decades. Yet there is no analysis of exposure or vulnerability which are likely to be significant factors in changes in insured losses.

Thanks for this comment. It indicates how the description of indexation in the original manuscript was insufficient. The description of loss data and indexation to a common year has been moved to section 2.2 in the revised manuscript. These losses have been indexed by industry experts to take account of the factors found to be significant for insured losses. The revised manuscript (lines 86-100) provides more details on how these national industry bodies have indexed their losses to take account of evolving claims.

Second, the paper shows an analysis of warming of northern Mediterranean waters, and shows that anthropogenic greenhouse gas emissions are driving these temperature increases. Yet, the link between the water temperature in the northern Mediterranean Sea and hailstorms is barely discussed, with only one line in Section 1 claiming that the "key area" is the Mediterranean Sea. The authors go on to make statements such as "given the coupling between northern Med temperatures and thunderstorm activity" and "a continuation of the warming trend in the Med corresponds to further increases in European hail damage" without sufficient evidence.

The revised manuscript presents more evidence linking Mediterranean Sea temperatures to hailstorm damage in Europe. The Introduction contains an overview, with a description of how warming waters humidify the air in lines 27-29 of the Introduction, then followed by the association of Mediterranean Sea temperatures with hailstorms in lines 31-34. Section 4 of the revised text gives fuller details on the connection from Mediterranean moisture to hail trends, in lines 171-193, including several studies showing a direct influence of the Mediterranean Sea moistening low-level air in past hailstorms. We trust the revised manuscript conveys how past research results have established a link from Mediterranean temperatures to hail damage.

While the paper is well written and admirably concise, the article shows incomplete trend analysis and lacks a clear and properly justified link between the Mediterranean Sea temperature and hail damage. Since correlation is not causation, much more analysis is required to show the impact of rising Mediterranean Sea temperatures on hail damage in Europe. Otherwise, the article shows only that greenhouse gas emissions are driving rising Mediterranean Sea temperatures – since there is already an extensive body of work on climate change effects on the Mediterranean Sea (e.g. Ali et al., 2022), is this result novel?

- We appreciate your feedback on the quality of writing.
- Both trend analysis, and the link from Mediterranean to hail damage, are discussed in the paragraphs above.
- To our knowledge, the use of DAMIP climate model results to quantify the relative contributions of external forcings on Mediterranean temperatures is new. For instance, Ali et al. (2022) describe temperature changes but neither identify nor discuss the relative roles of greenhouse gases and aerosols toward the warming over the past four decades.

I have made some specific suggestions below, but overall I would suggest that the authors a) consider changes in exposure and vulnerability in concert with changes in damages when performing trend analysis, and b) thoroughly link rising Mediterranean Sea temperatures to hailstorm activity (specifically, as compared to overall thunderstorm activity) in Europe.

Thanks, we have addressed both these points in the revised manuscript, as discussed above.

Specific comments

1. Lines 15-25: In the introduction the authors should be more specific – what is meant by "recent times"?

- "recent times" replaced by "past few years" (now at line 221 of revised manuscript).

Were the June 2021 losses caused by hail or by flood as hinted at by the authors mentioning saturated soils?

- the revised text is clearer (lines 221-222): "with 4.5 billion USD of insured losses from severe thunderstorms in Europe during summer 2021"

What is "similar magnitude" in the case of the Munich storm?

- this is spelled out in line 226 of the revised text "… since the multi-billion loss in the Munich hailstorm of 1984"

"A couple of decades" should be replaced by the actual time period examined.

- this sentence is removed from the revised text

2. Lines 75-76: The question with insurance loss data is always the proportion of the trend owing to change in the number or type of insured objects (ie the exposure and vulnerability part of the risk). See for example Strader et al. (2024) for tornado risk. The authors should comment on this aspect of uncertainty, and whether they think it plays a big role in the trends they present here.

The uncertainty in the indexation of older event losses to the present day (or more generally, a common index year) is mentioned in lines 199-200.

Note that the indexation of loss timeseries from national insurance bodies consider both the number and type of risks. In general, the insurance industry has been developing data and methods over a few decades to index their loss experience, because they place much value in knowledge derived from recorded loss data. We hope this message is conveyed clearly in revised text of lines 86-100. A summary of hail trends from the two types of studies (hazard- and loss-based) is given in lines 244-250 of revised text, and it is repeated again in the Conclusions.

3. Line 89: "Past research points to a warming climate causing more damaging hail in Europe". Yes, but the uncertainty must always be addressed because there remain many unknowns, as the authors have mentioned previously with e.g. references to Raupach et al. (2021). The authors should include the uncertainty in this statement.

This specific sentence is removed from the revised text.

The revised text provides estimates of rising hail trends as ranges, e.g. lines 244-245 and lines 279-285, to convey uncertainty. It includes a discussion of sources of uncertainty, e.g. lines 196-201, and suggests future research into reducing the uncertainty in the Conclusions (lines 281-282). We also have a new sentence in lines 283-284 of revised manuscript which contains our best understanding of all evidence: "Uncertainty is large, though large-scale trends in the higher-risk area are positive from almost all studies".

4. Line 125: The Butterworth filter and its use requires a reference.

A reference to Butterworth (1930) has been added.

5. Line 187: "rising trend in the European hail climate" – this needs more specificity, since observed trends depend heavily on whether frequency or severity is considered, the geographical region, whether only hail of certain sizes is considered, etc.

This phrase is from a sentence which contained more specific details – the rising trend was "from hailpad observations, insured losses, and raw weather ingredients for large hail". Nevertheless, the sentence was removed from the revised manuscript, and lines 273-284 in the Conclusions section contains more specific details on the rising trends.

6. Line 194: "Rising temperatures of local seas humidify the low-level air, which intensifies thunderstorms leading to more severe hail". The key word here is "local". How much effect would rising Mediterranean temperatures have on hailstorms far inland in Europe? This kind of link needs to be much further explored in this article.

The intention of the article is to investigate Europe-wide behaviour, hence the focus on the higher-risk areas which contribute the most to Europe-wide risk. To avoid confusion, we have reviewed the entire manuscript to clarify our intention to study large-scale behaviour over the higher risk areas.

The revised manuscript also includes discussions of how the Mediterranean affects these high-risk areas (e.g. lines 31-34 of Introduction, lines 171-180 of Section 4, lines 273-275 of Conclusions).

A more detailed study to estimate the impact of Mediterranean warming on hail trends by location is beyond the scope of this article, though we do highlight this as a potential topic for future work, in lines 190-192, and in the final paragraph of the Conclusions.

7. Line ~200: While aerosol changes have temperature effects, including on the Mediterranean as discussed here, they also have separate effects on thunderstorm activity that are highly uncertain and may exacerbate or modulate the changes owing to increased Mediterranean Sea temperatures. The authors should comment on this.

Various research has identified the cause of the recent trends in hailstorm activity as being mainly due to increases in low-level moisture, and these are referenced in the text (Kunz et al. 2009; Mohr and Kunz, 2013; Rädler et al., 2019; Battaglioli et al., 2023; Wilhelm et al., 2024). This explanation of hailstorm trends has become well established. Given the length constraints of a Brief Communication, we cannot extend the scope to discuss possible higher-order effects, such as trends in aerosol concentrations and their size distributions.

Technical corrections and typos, etc

1. Line 42: Remove repeated "more recently".
This paragraph was re-written and does not contain two consecutive sentences beginning 'More recently…'.

2. Line 83: Suggest removal of "more accurate" since CAPE and wet-bulb temperatures measure different things.
All mention of wet-bulb temperatures is removed from the revised manuscript.

References

Ali, E., W. Cramer, J. Carnicer, E. Georgopoulou, N. Hilmi, G. L. Cozannet, and P. Lionello, 2022: Mediterranean region. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, H. O. P¨ortner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegr´ıa, M. Craig, S. Langsdorf, S. L¨oschke, V. M¨oller, A. Okem, and B. Rama, Eds., Cambridge University Press, Cambridge, UK and New York, NY, USA, doi: 10.1017/9781009325844.021.

Raupach, T. H., and Coauthors, 2021: The effects of climate change on hailstorms. Nat Rev Earth Environ, 2 (3), 213–226, doi:10.1038/s43017-020-00133-9.

Strader, S. M., V. A. Gensini, W. S. Ashley, and A. N. Wagner, 2024: Changes in tornado risk and societal vulnerability leading to greater tornado impact potential. npj Natural Hazards, 1 (1), 20, doi:10.1038/s44304-024-00019-6, URL https://doi.org/10.1038/s44304-024-00019-6.