

Review of NHESS-2024-210

Re-review of NHESS-2024-210. I thank the authors for their responses to my comments from my first review and for the significantly refocused and much improved article.

In my last review I suggested 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. The authors have better explained how their loss estimates are normalised for exposure and vulnerability changes, which is helpful for part a). For part b), the authors have relied on a review of previous studies that show the importance of low-level moisture for convection-prone (not always hail) environments. The importance of low-level moisture is now well established, but the link from rising Mediterranean temperatures to severe hail trends is still not thoroughly made.

The secondary aim of the paper is to “quantify the link from Mediterranean Sea warming to its impacts on hailstorm risk in Europe”. The authors have not succeeded in this aim. There is no quantification in the paper; rather the two trends are analysed in parallel. At a minimum, I suggest that the authors quantify the correlation between Mediterranean temperatures and hail damage or hail-prone environments in the historical period. Do years in which the Mediterranean is warmer produce more severe hail? How much of the variability in hail losses is (statistically) explained by variability in Mediterranean temperatures? Plotting the two timeseries together would also help show a relationship.

Secondly, the authors should take great care in their wording of conclusion statements so that the uncertainties inherent in this study are well explained – I show specifics below. While I do not doubt that the warming Mediterranean plays a role in the trends in severe hail in Europe, this study does not yet show a convincing link. I hope that my comments below will help to improve the manuscript.

Specific comments

1. Lines 32: The cited article by Kunz et al. (2018) does not show a direct link between Mediterranean moisture and hailstorms.
2. Line 54: The authors analyse the variable “tas”, or near-surface atmospheric temperature,

rather than model variables for sea surface temperature which may be different. They compare these data to historical sea surface temperature in Figure 3. The authors should mention this difference and explain their choice. In Figure 3, the agreement of the historical simulations with observations is not particularly strong, with observations showing much more variability. The authors should comment on this discrepancy in variability.

3. Line 181: The authors write “A number of studies identify increases in low-level moisture as being the main cause of rising hailstorm risk across Europe over the past few decades” – but no references are given. The authors should cite exactly which studies show this, because not all the studies they cite in the following paragraph show that low-level moisture is the main driver of increases in hailstorm risk – rather some show the importance of low-level moisture in more-general convective environments, of which hail environments are a specific subset.
4. Line 191: The authors write that “it is clear that a warming Mediterranean is a primary contributor to the trends in hail risk in key parts of Europe”. The authors have shown that moisture increases are often linked to increases in convective storm environments, but the link to trends in hail risk is not clear. Other factors such as changes in melting of hailstones and local changes in convective inhibition may affect hail hazard, while risk changes are also affected by changes in vulnerability and exposure. I would suggest allowing for more uncertainty by replacing this line with “At the present time, it is likely that a warming Mediterranean is a primary contributor to the trends in the occurrence of convective environments in some parts of Europe”.
5. Around line 215: The authors use “hail risk” when they may be referring to hail hazard. I suggest only using the word “risk” when exposure and vulnerability are also taken into account in these reported results.
6. Line 238: “both trends are significantly different from zero at the 1% level” and similar lines – which statistical test is used for significance statements?
7. Line 275: “are driving hail trends since about 1980” – there is not sufficient evidence for this claim. Trends in hail are highly uncertain and complex, with large geographical inhomogeneity, and there is not one single driver.
8. Lines 275–278: “Recent trends in hail damages over these higher-risk parts of Europe were reviewed to measure the impacts due to Mediterranean warming.” This study does not measure the impact on hail due to Mediterranean warming – there is no quantification. Rather, the study shows that a) the Mediterranean has warmed, b) low-level moisture from the Mediterranean is important for convection, c) other published severe hail trends show increases over Europe, and d) hail damages have also increased over Europe. The link between a) and c) and d) needs to be made stronger and it is not shown whether the Mediterranean temperatures are the key driver amongst many influences on severe hail production.

References

Kunz, M., U. Blahak, J. Handwerker, M. Schmidberger, H. J. Punge, S. Mohr, E. Fluck, and K. M. Bedka, 2018: The severe hailstorm in southwest germany on 28 july 2013: characteristics, impacts and meteorological conditions. *Quarterly Journal of the Royal Meteorological Society*, **144** (710), 231–250, doi:10.1002/qj.3197, URL <https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3197>.