Many thanks to Harald Richter for the valuable additional comments and questions. Based on these, we were able to further improve our article. The comments point out that more research is needed, for instance to determine the quality in wind shear simulations in complex topography in reanalyses. We hope that the answers and changes in the article are satisfactory.

Second Review of WCD-2021-25

Title: Multi-day hail clusters and isolated hail days in Switzerland – large-scale flow conditions and precursors

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Recommendation: Minor revision

I very much appreciate the significant effort that the authors have invested to address all the comments made by the three reviewers. Such efforts show the desire to arrive at a stronger publication, and the manuscript at hand is no exception. I have a few broader considerations that the authors might to address beyond their initial response, and I consider these as minor overall.

The response to the wind shear query of my first review mentioned that a subset of the hailstorms captured in the hail cases for this study were from supercells. On conceptual grounds these storms require deep layer shear which may or may not be captured adequately on the 0.5_o ERA-5 dataset in the vicinity of substantial terrain (which would not be captured adequately on 0.5_o grid). I see a risk of a proportion of the readership might gain a similar impression, which can preemptively be addressed somewhat more that it has to date. I recommend the following considerations for inclusion.

[1] Hail of golf ball size or larger is most likely due to storms that are organized due to deep layer shear interaction (what proportion of the hail reports in the insurance dataset are in that category?)

Unfortunately we do not have information on the hail size from the insurance reports, we only know that damages to cars usually only occur for hail sizes > 2 cm.

[2] Can anything be said about the deep layer performance of ERA-5 around significant orography (I am not asking for this step, but has anyone ever plotted observed or km-scale modelled deep layer shear against ERA-X deep layer shear?)

We are not aware of any validation of ERA-X deep layer shear against observations in complex orography. Taszarek et al. 2021 compared wind shear in ERA-5 with wind shear derived from rawinsondes in Europe and North America and found that ERA-5 tends to underestimate wind shears and that especially extreme wind shear (>=25ms-1) are not well represented. There is a study by Graf et al. 2019 validating regional climate model winds against observations and these comparisons clearly show that the regional climate model simulations fail to capture the diurnal wind systems in valley locations. These thermo-topographic wind systems are important for the formation of shear in Switzerland and in the pre-Alps on days with severe convection (see e.g., Trefalt et al. 2018). It may be that the assimilation of observations into ERA-5 solves this issue, but we do not know. We therefore include a sentence in the summary and discussion section stating that the winds in ERA-5 close to complex topography may not include important thermo-topographic wind systems due to the coarse model resolution.

We added the following sentence in lines 369-372:

Thermo-topographic wind systems, such as diurnal winds in valleys, are important for the formation of wind shear in the pre-Alps on days with severe convection (see e.g. Trefalt et al., 2018). These winds are potentially insufficiently resolved by the coarse-resolution reanalysis, which could explain this lack of difference between clustered and isolated hail days.

The restate the above thoughts once more has they summarize the main gap in demonstrating that ERA-5 can be meaningfully applied to flows around the Alps in the lower troposphere.

Among the very minor tidy-up considerations are:

• Clustering hail days: I can see that the amount of detail required to explain the approach can be seen to detract from the paper's main messages. On the other hand, a study should provide the minimum amount of information that allows a (rather keen) scientist to reproduce the results. Maybe the best compromise is an Appendix with the clustering details, or a reference to an external source? The allocation of two 5-day clusters to 12-19 day periods of clustered days seems to follow the principle of maximum 5-day period separation. This principle can lead to the 5-day periods extending beyond the actual hail days by 1 day. Is there a simple way of showing that integrating such non-hail days into the analysis is not going to majorly alter the results? I suspect this may be hard to show, and I do not consider it an essential inclusion.

Thank you for your suggestion. We now added another Appendix chapter that explains the definition of independent 5-day clustered hail day periods, similarly to the review answers (see below). To answer the last question: The independent 5-day clustered periods sometimes include non-hail days (4 hail days + 1 non-hail day), but these non-hail days are not included in the hail-day analyses at all. These non-hail days are only considered in the analysis if they precede the hail-day clusters and, therefore, are counted as non-hail days before clustered hail days ("d-1" days in Table 1).

The second paragraph in Appendix C now says (see lines 431-451):

The clustered hail days are by nature dependent. We therefore apply a 500-times-repeated resampling to all clustered and isolated hail days such that each of the 500 series contains only serially independent data. Isolated hail days are by nature independent; this category does not need any additional treatment to ensure independence. However, continuous periods with clustered hail days should only be sampled once per resampling. To split all periods of clustered hail days into independent 5-day clustering periods, we apply an algorithm. This algorithm treats clustered periods lasting up to 11 days differently than clustered periods longer than 11 days. In the latter case, the > 11-day-period is divided into periods of 5 days that have at least 2 days between each other. Concretely, the first and last 5 days defined as clustered hail days are chosen (see e.g. DOYs 147–159 in the year 2003). The 5-day period in ≤ 11-day situations is set to go from the Xth to the Yth day, with X and Y being defined as follows:

$X = \text{floor}(n/2) - 1$

$Y = \text{floor}(n/2) + 3$

with n being the number of days in a period of clustered hail days and "floor" denoting that the result of the fraction is rounded down to the next integer. If a period of clustered hail days lasts e.g. 7 days, then the 5-day period we call independent will start on the second and end on the sixth day. For the clustering period in 2004 (Fig. 2), some clustered hail days have the sequence no hail (0) and hail days (1) "11011101". In this case, the 5-day period chosen by the algorithm contains only 3 hail days (01110), despite being marked as clustered by their attribution to neighboring 5-day periods. In this case the choice is corrected by displacing the 5-day period to one day earlier. Consequently, the number of hail days per independent clustering period is always ≥ 4. This criterion of independence has the consequence of not including all potentially available clustered hail days. North and south of the Alps, this treatment additionally removes 29 and 13 out of 164 and 102 clustered hail days, respectively.

References:

Taszarek, M., Pilguj, N., Allen, J. T., Gensini, V., Brooks, H. E., and Szuster, P.: Comparison of Convective Parameters Derived from ERA5 and MERRA-2 with Rawinsonde Data over Europe and North America, Journal of Climate, 34(8), 3211-3237, https://doi.org/10.1175/JCLI-D-20-0484.1, 2021.