

## Response to Reviewer's Comments: Round 2

Reviewer's comments in black. Authors' original response in red. Authors' response this round in purple.

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The revised version of the manuscript shows improvement as the authors have taken into account some of the questions and suggestions raised by the reviewers. However, it is disappointing to note that several important points raised by the reviewers were not adequately addressed or considered by the authors, but rather simply dismissed by stating "no change in the manuscript."

We are sorry that our response has led to the reviewer feeling this way. It was not our intention to dismiss the comments by the reviewer. We felt that we have tried to understand each comment, consider our response, then argue for a course of action that we were comfortable doing. None of our responses were intended to dismiss the comment without consideration.

That said, we disagree that we did not adequately address the reviewer's comments in our response. From our perspective, we responded professionally and thoroughly to each of the reviewer's comments, justifying our choices and responding to the reviewer's concerns. We did not understand some comments, we disagreed with others, and we felt that not all comments warranted a change to the manuscript. That is why we wrote "no change to the manuscript" for a minority of our responses. That statement is commonly used in reviews and was not intended to dismiss the reviewer's comments. It was merely a factual statement stating we felt that our response was sufficient and no further change was needed in the manuscript.

In my review, I emphasize the need for the authors to adequately address and consider the major revision points 4 and 5, as well as the minor points 3, 5, 8, 10, 11, and 13 (second paragraph, although this is not the most critical issue).

In this next round of reviews, we have endeavored to revise the manuscript where possible to address the reviewer's concerns. We hope you find them acceptable.

### Major Point 4:

4. Is a hail day one with at least one report across Europe (that would make no sense), or have you considered some threshold? For example, is a day with only one 2 cm report considered the same as a day with thousands of reports and hailstones larger than 10 cm? That would be strange.

This study aims to look at the ESWD as a whole. Therefore, yes, the entirety of Europe has been considered. Indeed, one hail day is one where at least one hail observation of 2+ cm has been reported. The concept of a hail day is similar to that of a lightning day or tornado day, concepts that are well accepted in the severe weather community. In principle, hail days should be more robust to these fluctuations in reporting individual hail reports, which is why we have showed this quantity. No change to the manuscript.

Furthermore, it makes no sense to define a hail day for the whole of Europe, with its wide variety of local climates. I would rather suggest limiting it to countries with a high number of reports, for example. I would also suggest considering different thresholds for both hail size and number of reports.

The point here is not to look at individual days, but to put this in perspective on the continent over a longer time period. In principle, hail days should be more robust to these fluctuations in reporting individual hail reports, which is why we have showed this quantity. Thus, the hail-day concept is exactly intending to solve the problem the reviewer identified. The reviewer's proposed solution makes a rather simple concept of a hail day into a much more complicated matter. Furthermore, the reviewer's solution of concentrating on countries with higher reports would not remove any variability within climates. No change to the manuscript.

As we have written previously, previous studies on convective phenomena consider the concept of a "day", including over large areas such as Europe (e.g., Pucik et al. 2019). For example, Punge and Kunz (2016) write that hail days are also aligned with information that the insurance industry uses, as their portfolios cover regions larger than countries and hailstorm outbreaks may cover more than one country.

Moreover, why would an arbitrary threshold for a number of reports over a number of locations be needed to be considered a hail day? Why would that number be any different from the value of 1, when the reports used are plausibility checked? It is unclear how one would pick a threshold, justify it, and have it be meaningful, in any way that makes more sense than how we have done it, which again is standard in severe-weather climatologies.

Looking at hail days across Europe as a whole for the entirety of the dataset helps to understand the spread of the data over time. This information is then used when considering annual and diurnal cycles, as some countries have more complete records in the ESWD. Hence, this would favor these countries when looking at Europe as a whole. Furthermore, by looking at hail days and reports (Figure 2), more recent years possess a smaller number of hail reports for the same number of hail days. This result can be interpreted as the ESWD as a dataset has gained spatial extent in hail reporting, making it a more valuable resource. Additionally, by comparing hail days and hail reports on an annual cycle (Figure 3), there is a discrepancy in hail reports vs hail days per month. This discrepancy could suggest many things, such as hail being seen more widely across Europe during the early summer season, or an underlying nonmeteorological factor that would affect the number of reports.

For these above reasons, we strongly argue that it makes perfect sense to discuss hail days across the entirety of Europe. We retain the concept of hail days in the manuscript. We have added text at lines 124–128 to justify our choice of inclusion of hail days.

"We analyzed not only the number of hail reports, but the number of hail days, as well. Hail days are a more robust measure of hail occurrence and helps minimize variability due to variability in hail reporting across different countries. Hail days are also useful for certain purposes. For example, Punge and Kunz (2016) wrote that hail days are also aligned with information that the insurance industry uses, as their portfolios cover regions larger than countries and hailstorm outbreaks may cover more than one country."

That being said, we appreciate that the European continent contains many different climates. Hence, the climatology of hail may differ among the various countries. Therefore, we have added extra country-by-country information for those countries with 100 or more reports during the period 2000–2020, adding a new Figure 4 that illustrates the annual distribution of hail days by country. We have also added a new Figure 7, which shows the hourly distribution of large-hail reports by country for countries with 100 or more reports. Both figures are supplemented with accompanying text. We hope these changes address your concern.

5. Point 4 also refers to the other analyses, such as the annual and diurnal cycles. It is mentioned that Púčik et al. (2019) divided the study area into at least two parts due to the different climates. Why did you not follow this?

Although we agree that Europe encompasses many climates, how to divide these up can occur in numerous ways. We chose not to classify different climatological zones, in part because of this ambiguity and in part because this was beyond the scope of the research. For example, one may choose to differentiate between a more maritime or more continental climate, but these may then contain other factors such as mountain ranges or plains. Hence, we decided to stick to a general overview of the reported distribution of large hail in Europe. No change to the manuscript.

In fact, the last revision of the manuscript had included a new figure (then Figure 4) that addressed the variation in monthly distribution across the European countries. That new Figure 4 comprised 24 horizontal bar charts for 24 countries with 100 or more reports. We had also added a new figure (then Figure 13) that addressed the variation in hail-size distribution across the European countries. That new Figure 13 comprised 24 horizontal bar charts for 24 countries with 100 or more reports. A similar plot for diurnal cycle was not performed. We noticed that the reviewer did not comment upon the addition of these figures, which helped address their concerns about the regional variability. Perhaps the reviewer missed these two new figures?

We have added a new figure (Figure 7) that shows the country-by-country distribution of hail reports by hour. We hope this figure and its accompanying text addresses your concern.

We analysed the data initially on a European-wide basis, and then on a country-by-country basis. Several figures in our manuscript address the regional variability of the dataset by country: Figures 4, 11, 12 and 13, and Table 1. Indeed, even within these countries there will be climatic variations. But, the aim of this study was not to construct a detailed intercomparison between individual large-hail climatologies on a country level, but to understand more about the data in the ESWD and to evaluate if similar results can be produced to other studies when considering a lower quality-control level.

We have added a number of new figures in two iterations of this manuscript and new text addressing the reviewers' concerns. We hope these revisions are suitable.

### **Minor Point 3:**

L44-45: You may add that most of the hail climatologies / statistics (e.g., those cited in Touvinen et al., 2009) are outdated

What the reviewer means by “outdated” is unclear and unfair to these studies. Indeed, some of the studies mentioned were published a number of years ago as implied by our statement of ““A summary of past European hail climatologies”. However, this does not mean their results are necessarily outdated. Moreover, readers would understand that a study published in 2009 is representative of the time in which it was published and of the dataset from which it was derived. Therefore, we disagree with the premise of this comment. No change to the manuscript.

We fail to see why the reviewer is so adamant about denigrating perfectly good climatologies from the past by forcing us to use the word “outdated”. Although we appreciate that some of the studies are a few years old and that new studies have been published since, such studies still offer insight into the current knowledge of hail over Europe. We have already defended our choice not to denigrate these studies. Readers will recognize that a study from 2009 is of its time, not of the present time. At what point does a study become “outdated”? Five years after publication? Ten years? Thirty years? It is unfair to the previous literature. We strongly disagree with the reviewer on this point. We already mention a more recent summary of hail studies within the same sentence (i.e. Punge and Kunz 2016). Thus, readers wanting a more recent review are already referred to this source.

Nevertheless, we can further distinguish between Tuovinen et al. (2009) and Punge and Kunz (2016). We have revised this sentence to “...Tuovinen et al. (2009), and an updated review was published by Punge and Kunz (2016).”

We have also added a new paragraph about the newer climatological studies on hail, starting at line 52.

“Climatologies of European convective storms and their impacts have been constructed using a number of datasets. For example, some studies have examined the climatology of convective storms using remote-sensed data such as lightning, radar, and satellite (e.g., Punge et al. 2017). Others have examined the environments that favor such storms, such as through reanalyses or soundings (Rädler et al. 2018; Taszarek et al. 2017, 2018, 2019) or reanalyses coupled with hailpad data (Sanchez et al. 2017).”

We hope these revisions are suitable.

#### **Minor Point 5:**

5. I miss a better motivation and scientific objectives of the paper. “Increasing the size of the dataset through...extending the period of analysis” is too weak when only 2 additional years are considered.

This comment is unfair. The reviewer has selectively edited this sentence to misrepresent what we actually wrote in the original submission.

“In the present article, we explore whether increasing the size of the dataset through lowering the quality-control levels of the reports and extending the period of analysis yields comparable results, increasing the generality of Púčik et al.’s (2019) results.”

So, our analysis was also about adding cases through lowering the quality-control levels of the reports, not only extending the time period. These two changes resulted in an increase in the number of reports from 39,537 (Půčik et al. 2019) to 62,053 (present study), a 57% increase in the size of the dataset.

“In doing so, we also document the reporting characteristics of the database as a function of time both throughout the 20th century and within the last 20 years. In particular, we seek the possible existence of a relatively homogeneous period of time in the database that could be used as a baseline for climatologies and climate-change studies.”

But, our study is about more than just increasing the size of the dataset. We also had different purposes to Půčik et al. (2019), which again were not mentioned by the reviewer.

Thus, we feel that we have clearly stated our motivation and scientific objectives, despite the manipulated and truncated quotation provided by the reviewer. No change to the manuscript.

Repeating what the manuscript already states: The purpose of this manuscript is to create a dataset from reports with a lower quality level than used in a previous study (i.e., Půčik et al. 2019) to see if they provide similar results to higher quality-controlled reports and to determine if it is possible to identify a relatively homogeneous period of time to be used as a baseline for climate-change studies. These two pieces of text appear in the second-to-last paragraph of the introduction (right before the paragraph that describes the outline of the manuscript). This is a common location for authors to place the scientific objectives of a journal article, which is what we have done.

Moreover, we have justified the motivation and objectives of the manuscript already at the former lines 69–74, 82–84, and 114–115. We believe that the motivation and scientific objectives are clearly stated in multiple locations within the first two sections of the manuscript. We have already responded appropriately to the reviewer.

We want to emphasize again that the reviewer selectively edited our text to manipulate the interpretation of our words and to omit something we said we did, which was the principal point of doing this research project. We believe we authors have a responsibility to report this kind of unethical behavior.

#### **Minor 8:**

L157: “...ability to detect reports linked to the same event, and hence have removed duplicate events from the dataset”. This would make no sense at all and is not the case. In the papers cited (e.g. Wilhelm et al., 2020) it is clear that a single streak is covered by several reports.

The point made here is that fewer reports have been needed for the same quantity of hail days over recent years than previously. Therefore, we are just speculating a few reasons for this. No change to the manuscript.

Just a small correction to note in this comment: The citation should be Wilhelm et al. (2021), not (2020).

We have deleted the phrase "and hence have removed duplicate events from the dataset".

**Minor 10:**

10. L188: Can you briefly describe how you converted UTC to LT?

All reports have the country of origin listed and all times are in UTC. By looking at each country on an individual basis, these were converted to LT taking daylight savings into account. No change to the manuscript.

We did not initially understand the question posed by reviewer. We now understand that there may have been a misunderstanding regarding local solar time and local legal time by time zone. In the manuscript, we converted the times from UTC to these local legal times based on each different country's time zones. We did this by searching their corresponding summer times, as the majority of reports were from April to September.

The text has been changed to the following:

"When corrected for local legal time (LT) based on each country's official time zone...."

Additionally, we have added a new Figure 7 showing the country-by-country breakdown of reports based on the time of day. There does not seem to be any particular pattern in the predominant time period for hail to form across Europe.

**Minor 11:**

11. L191-192: see comment (9); Although the diurnal cycles of Kunz et al. (2020) have a resolution of only 3 hours, there are some differences, which may be due to different study areas?

In fact, Figure 4 (local time) in the present manuscript if converted to a bar chart and Fig. 2b in Kunz et al. (2020) are quite similar. Sure, small differences will be due to different study areas and different years, but we don't see that. No change to the manuscript.

The text has been revised to "These distributions are also similar to those from Kunz et al. (2020, their Fig. 2b) who found a peak during 1500–1800 LT for hailstorms in central Europe using all quality levels from the ESWD, although small differences (e.g., relatively more hail during 1200–1500 LT in Kunz et al. (2020) compared to Fig. 5) may be due to the different study areas between these two studies."

**Minor 13:**

13. L287-289: The main reason for the high number of reports in Germany is obviously that ESSL was founded here.

Yes and no. The ESWD grew out of other data-collecting efforts such as TorDACH (tornado dataset from Germany, Austria, and Switzerland). So, although there was a focus on Germany, it was not strictly limited to the founding of ESSL. No change.

We have added new text at lines 331–334 to address the reviewers' concern.

It should be mentioned that in some countries severe weather reports are collected by other institutions, e.g. KERAUNOS in France. Moreover, crowd-sourcing via meteo apps is well known and emerging in some countries, such as the MeteoSwiss app, which has collected >100,000 reports in recent years (compared to only 266 ESWD reports). So we should not blame spotters for being less enthusiastic.

The wording as written is precise. There are two factors in play here, and our text is clear in both of those factors. Storm-spotter networks may be more or less enthusiastic about collecting reports within their own countries ("existence, size, and enthusiasm of spotter networks within each country"), and such networks may vary in how effective they are at contributing those reports to the ESWD ("variations in the ability or enthusiasm of citizens to input into the ESWD"). No change to the manuscript.

We have added this information into the manuscript about KERAUNOS and the MeteoSwiss app, etc. at lines 340–341.

It is crucial for these points to be thoroughly addressed before the manuscript can be accepted for publication. By doing so, the authors can demonstrate a commitment to improving their work and addressing the concerns of the reviewers.

Ultimately, it is the responsibility of the authors to carefully consider and respond to the concerns raised by the reviewers. The peer review process is designed to ensure the quality and rigor of scientific research, and your thorough evaluation and constructive feedback play a vital role in upholding these standards.

Again, we felt that we had addressed the reviewer's concerns in our original response. In addition, there were some comments where we disagreed with the reviewer or the reviewer did not communicate their intention clearly enough. We apologize for any misunderstandings. We did not feel that such comments required revising the manuscript per se at that time.

Nevertheless, we have revisited those previous concerns raised by the reviewer. We have created new figures and added new text where appropriate. We hope these new revisions in this round are suitable.

Moreover, we were not pleased to see the reviewer selectively edit our text to change our intended meaning. This behavior is unacceptable and needs to be addressed so it does not happen in the future.