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Discussions

Interactive comment on "Radar-based assessment of hail frequency in Europe" *by* Elody Fluck et al.

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The paper "Radar-based assessment of hail frequency in Europe" is targeted on climatology of severe convection storms (SCS) based on 10 years of radar data covering a large European region. The topic is very important and suitable for NHESS. The analysis covers a relatively large number of years (considering typical radar records) and geographic domain.
#The authors are very grateful to the reviewer who found the topic of the article important and suitable for NHESS. We are thankful for all the questions, comments and suggestions, which will all be considered in the revised version of the paper.

My main concern is if we are really sure these are hail cases. The paper, is it is now, is not clear about this. The text some times refer the data set as SCS and

sometimes as hail cases. On one hand, it seems some validation has been done: "Tests with long-living SCS tracks were compared with hail reports archived by the European Severe Weather Database (ESWD) operated by the European Severe Storms Laboratory (Dotzek et al., 2009) along the reconstructed storm trajectories to assess the reliability of CCTA2D (not shown). In most cases, the ESWD reports were located close to the center of SCS tracks." (Lines 169-172). But, just next to it, at the beginning of the results section, there is a "disclaimer": "Note that this climatology represents the spatial distribution of convective cells with high reflectivity, but not directly of hail. The term hail days used in the following refers to the exceedance of reflectivity, but not to confirmed hail observations" (Lines 180-182). I understand the first case refers to tracks while the second to the spatial distribution, but I think it would be better to clarify in a targeted section whether or not there is any validation that the analyzed storms are indeed hail events. Also, through out the text try to be more consistent in the use of SCS vs. hail events according to the level of assurance of the nature of these events. Furthermore, validation seems quite crucial here, as without it, the data set may not represent hail events. So I encourage the authors to present the validation done against the hail reports from ESWD and if possible to extend it.

\# The authors understand the concern of the reviewer. A clear identification of hail within the SCS tracks and especially a separation between hail and heavy rainfalls is not possible giving the lack of comprehensive hail observations and the use of a proxy. However, in the Puskeiler et al. (2016) paper, which is based on similar methods (in the 2 D version), we have computed different skill scores using different insurance loss data. Furthermore, in the recent paper of Kunz et al., (2020), the authors separate the SCS events (same SCS data as in this study) from hailstorm events (HS) by assessing the presence of hail using ESWD reports in the vicinity of SCS tracks. Out of 26 012 SCS events in total from 2005 to 2014, only 985 events could be considered as hail events. However, several hail events that are not observed and captured by ESWD

reports lead to the large reduction of cases. Indeed, out of the 4 577 ESWD reports available from 2005 to 2014, Germany counts most of the reports with 76.5% followed by France with 21.1% then Belgium with 7.1% and finally Luxembourg with 0.7%. We will add a statement on the reliability and skill referring to the two papers.

Other comments: It would be good to provide a short background on hail forma-tion, under what meteorological conditions we should expect hail events. This would help in understanding the interpretation of the presented results.
We will add a short background paragraph about hail formation and environmental conditions in the revised version.

The data set includes radar data from two countries which goes some different processing procedures. To be sure this does not add any bias in results – is there any overlap region where analysis from both data sources can be compared?
A huge effort is done by both French and German weather services to homogenize their radar products, in order to provide among others, high-resolution European radar composites within the program OPERA. Thus, a further quality check step compared to inland radars is applied on neighboring countries. An overlap region between the two countries is for example present over the Rhine Valley including Northeast France and the Southwest part of Germany. The authors gave a special attention to this area at the beginning of their research to "twist" the tracking algorithm and compared reflectivity values from both countries during few hail events (For example on 28th July 2013 during the severe thunderstorms and hailstorms that affected Southwest Germany (Kunz et al., (2020)). Even if the reflectivity values differ lightly from one country to another, the tracking algorithm includes corrections (which will be detailed in the revised article) to get the best tracking location. Furthermore, the advection correction used after the tracking permits a smoothing of the reflectivity values to get uniform values with no apparent differences over overlapped regions. We will comment on those points in the revised version.

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Discussion paper

Lightening filter: "If high reflectivity during a day occurs without lightning, the values at the affected grid points are set to zero." (Line 127-128): why only during day? Are you sure this filter is not too aggressive? Can you provide any information on percent of hail storms that are not associate with lightening? if I understand correctly these storms will be filtered out from the analysis and it is important to verify their fraction is not substantial.

#More details about the lightning filter methods will be added in the revised manuscript. The filter runs for day and nighttime (day in the above sentence is meant as 24-hour period); we will clarify this. Note that the lightning filter only marginally affect the results as shown in Puskeiler (2013; PhD thesis, but only in Germany).

Split and merge: the authors write that "Special attention is given to cell splitting and merging" (Line 154). Why is that? I did not find in the results any consideration of the splits and merges that were detected.

#Sorry, this is formulated misleadingly and will be corrected. This attention is considered during the tracking calculation only. It can happen that a part of a storm splits from the main path and develops into left (or right)-moving supercells leading to hail on the ground. This happened for example on 28th July 2013. In order to avoid any hail underestimation (overestimation), a splitting (merging) option in the tracking algorithm is necessary. Furthermore, the physical characteristics of hail swaths could be compromised/wrong without splitting or merging options. The results in this study present a global hail-statistic including both merging and splittings.

Line 277: "As shown in Figure 5 the annual variability is very high and without any trend" – for 10 years of data I would not consider a trend for 10 years of data.
We will reedit this sentence.

Line 283-285: "large-scale lifting (e.g., related to differential vorticity advection) could have led to an increase in convective available potential energy (CAPE)

and a low convective inhibition (CIN). The combination of high moisture in the boundary layer, low CIN, high CAPE and lifting mechanisms may give rise to a substantial increase in SCS." It is not clear if this is an assumption or analysis. Why not to check reanalysis data for CAPE, CIN, air moisture anomalies? without it, I think this sentence is too speculative.

#We agree on your assessment and will delete this speculative statement. A recent article of Kunz et al., (2020) assess the ambient conditions during hail events for the period 2005 to 2014 using the same tracks and 2D radar data as this study. We will add a comment and present the main results in the revised paper version.

General comment: the authors provide a very detailed description of the pattern shown in the figures. In my opinion this is too lengthy and could be shorten. I leave this however for the author decision.

We will reread thoroughly this section and will delete what is not necessary. In particular we will delete the speculations given here.

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